GREENSBORO, NC Corporate
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SKA CONSULTING ENGINEERS

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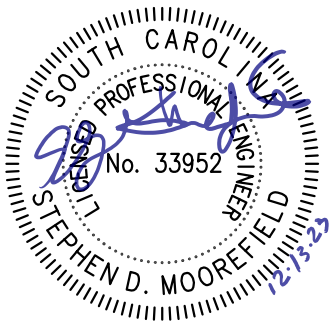
York County EOC
HVAC Replacement

Specifications

SKA Job Number: 230200.0

December 13, 2023

CONSTRUCTION DOCUMENTS



Stephen Moorefield, PE

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BID FORM

A. Bid Amount

Total Cost (HVAC Renovation) $_____

10% Contingency (Total Cost X 10%) $_____

TOTAL PROJECT BID: $_____

B. Acknowledgement of Addenda

If any Addenda are issued, Bidder hereby acknowledges receipt of all Addenda through and including:

Addenda: #1 ____ #2____ #3____ #4____ #5____

C. Contractor's Classifications and Subclassifications

SC Contractor's License Number(s):_____

Classification(s) and Limits: _____

Subclassifications (s) & Limits_____

D. List of Subcontractor(s)

Subcontractor(s) _____

_____

_____

_____

Signature Page - OFFERORS MUST COMPLETE AND SIGN THE FORM BELOW
The submittal must be signed by an authorized representative of the Offeror accepting all terms and conditions contained in this document and any addenda. Modifying the terms and conditions of this solicitation may result in your response being rejected.

COMPANY NAME	FEDERAL TAX ID NUMBER
COMPANY ADDRESS	CITY, STATE, ZIP+4
PAYMENT/REMITTANCE ADDRESS	CITY, STATE, ZIP+4
EMAIL ADDRESS	COMPANY TELEPHONE
PRINT NAME	TITLE
AUTHORIZED SIGNATURE	DATE

Minority Status

- ☐ Not Minority Owned
- ☐ African American Male
- ☐ Caucasian Female
- ☐ African American Female
- ☐ Aleut
- ☐ Eskimo
- ☐ East Indian
- ☐ Native American
- ☐ Asian
- ☐ Other (Please Explain)

Form **W-9**
(Rev. October 2018)
Department of the Treasury
Internal Revenue Service

Request for Taxpayer Identification Number and Certification

▶ **Go to *www.irs.gov/FormW9* for instructions and the latest information.**

Give Form to the requester. Do not send to the IRS.

Print or type. See Specific Instructions on page 3.

1 Name (as shown on your income tax return). Name is required on this line; do not leave this line blank.

2 Business name/disregarded entity name, if different from above

3 Check appropriate box for federal tax classification of the person whose name is entered on line 1. Check only **one** of the following seven boxes.

☐ Individual/sole proprietor or single-member LLC ☐ C Corporation ☐ S Corporation ☐ Partnership ☐ Trust/estate

☐ Limited liability company. Enter the tax classification (C=C corporation, S=S corporation, P=Partnership) ▶ _____

Note: Check the appropriate box in the line above for the tax classification of the single-member owner. Do not check LLC if the LLC is classified as a single-member LLC that is disregarded from the owner unless the owner of the LLC is another LLC that is **not** disregarded from the owner for U.S. federal tax purposes. Otherwise, a single-member LLC that is disregarded from the owner should check the appropriate box for the tax classification of its owner.

☐ Other (see instructions) ▶

4 Exemptions (codes apply only to certain entities, not individuals; see instructions on page 3):

Exempt payee code (if any) _____

Exemption from FATCA reporting code (if any) _____

(Applies to accounts maintained outside the U.S.)

5 Address (number, street, and apt. or suite no.) See instructions.

Requester's name and address (optional)

6 City, state, and ZIP code

7 List account number(s) here (optional)

Part I Taxpayer Identification Number (TIN)

Enter your TIN in the appropriate box. The TIN provided must match the name given on line 1 to avoid backup withholding. For individuals, this is generally your social security number (SSN). However, for a resident alien, sole proprietor, or disregarded entity, see the instructions for Part I, later. For other entities, it is your employer identification number (EIN). If you do not have a number, see *How to get a TIN,* later.

Note: If the account is in more than one name, see the instructions for line 1. Also see *What Name and Number To Give the Requester* for guidelines on whose number to enter.

Social security number

			–		–				

or

Employer identification number

		–							

Part II Certification

Under penalties of perjury, I certify that:

1. The number shown on this form is my correct taxpayer identification number (or I am waiting for a number to be issued to me); and
2. I am not subject to backup withholding because: (a) I am exempt from backup withholding, or (b) I have not been notified by the Internal Revenue Service (IRS) that I am subject to backup withholding as a result of a failure to report all interest or dividends, or (c) the IRS has notified me that I am no longer subject to backup withholding; and
3. I am a U.S. citizen or other U.S. person (defined below); and
4. The FATCA code(s) entered on this form (if any) indicating that I am exempt from FATCA reporting is correct.

Certification instructions. You must cross out item 2 above if you have been notified by the IRS that you are currently subject to backup withholding because you have failed to report all interest and dividends on your tax return. For real estate transactions, item 2 does not apply. For mortgage interest paid, acquisition or abandonment of secured property, cancellation of debt, contributions to an individual retirement arrangement (IRA), and generally, payments other than interest and dividends, you are not required to sign the certification, but you must provide your correct TIN. See the instructions for Part II, later.

Sign Here	**Signature of U.S. person ▶**		**Date ▶**	

General Instructions

Section references are to the Internal Revenue Code unless otherwise noted.

Future developments. For the latest information about developments related to Form W-9 and its instructions, such as legislation enacted after they were published, go to *www.irs.gov/FormW9.*

Purpose of Form

An individual or entity (Form W-9 requester) who is required to file an information return with the IRS must obtain your correct taxpayer identification number (TIN) which may be your social security number (SSN), individual taxpayer identification number (ITIN), adoption taxpayer identification number (ATIN), or employer identification number (EIN), to report on an information return the amount paid to you, or other amount reportable on an information return. Examples of information returns include, but are not limited to, the following.

- Form 1099-INT (interest earned or paid)
- Form 1099-DIV (dividends, including those from stocks or mutual funds)
- Form 1099-MISC (various types of income, prizes, awards, or gross proceeds)
- Form 1099-B (stock or mutual fund sales and certain other transactions by brokers)
- Form 1099-S (proceeds from real estate transactions)
- Form 1099-K (merchant card and third party network transactions)
- Form 1098 (home mortgage interest), 1098-E (student loan interest), 1098-T (tuition)
- Form 1099-C (canceled debt)
- Form 1099-A (acquisition or abandonment of secured property)

Use Form W-9 only if you are a U.S. person (including a resident alien), to provide your correct TIN.

If you do not return Form W-9 to the requester with a TIN, you might be subject to backup withholding. See What is backup withholding, *later.*

SOUTH CAROLINA ILLEGAL IMMIGRATION REFORM ACT

CONTRACTOR CERTIFICATION

In accordance with the requirements of the South Carolina Illegal Immigration Reform Act, _____ ("Contractor") hereby certifies that it is currently in compliance with the requirements of Title 8, Chapter 14 of the S.C. Code Annotated and will remain in compliance with such requirements throughout the term of its contract with _____ ("Owner").

Contractor hereby acknowledges that in order to comply with requirements of S.C. Code Annotated Section 8-14-20(B), it will:

1. Register and participate in the federal work authorization program (E-Verify) to verify the employment authorization of all new employees; and require agreement from its subcontractors, and through the subcontractors, the sub-subcontractors, to register and participate in the federal verification the employment authorization of all new employees.

Contractor agrees to provide to Owner any documentation required to establish the applicability of the South Carolina Illegal Immigration Reform Act to the Contractor, subcontractor, or sub-subcontractor. Contractor further agrees that it will provide Owner with any documentation required to establish that the Contractor and any subcontractors or sub-subcontractors are in compliance with the requirements of Title 8, Chapter 14 of the S.C. Code Annotated.

Date: _____ By: _____

Title: _____

CERTIFICATION REGARDING DEBARMENT, SUSPENSION, INELIGIBILITY AND VOLUNTARY EXCLUSION LOWER TIER COVERED TRANSACTIONS 10/16

This certification is required by the regulations implementing Executive Orders 12549 and 12689, Debarment and Suspension, and 2 CFR Part 200, Participants' responsibilities.)

(BEFORE COMPLETING CERTIFICATION, READ INSTRUCTIONS BELOW)

(1) The prospective lower tier participant certifies, by submission of this proposal, that neither it nor its principles are presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

(2) Where the prospective lower tier participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

Grant Number: Assistance Living CFDA 21.027 **Name of Participant:**

Address of Participant:

Name and Title of Authorized Representative	**Signature**	**Date**

1. By signing and submitting this proposal, the prospective lower tier participant is providing the certification set out below.
2. The certification in this clause is a material representation of fact upon which reliance was placed when this transaction was entered into. If it is later determined that the prospective lower tier participant knowingly rendered an erroneous certification, in addition to other remedies available to the Federal Government, the department or agency with which this transaction originated may pursue available remedies, including suspension and/or debarment.
3. The prospective lower tier participant shall provide immediate written notice to the person to which this proposal is submitted if at any time the prospective lower tier participant learns that its certification was erroneous when submitted or has become erroneous by reason of changed circumstances.
4. The terms "covered transaction", "debarred", "suspended", "ineligible", "lower tier covered transaction", "participant", "person", "primary covered transaction", "principal", "proposal", and "voluntarily excluded", as used in this clause, have the meanings set out in the Definitions and Coverage sections of rules implementing Executive Orders 12549 and 12689.
5. The prospective lower tier participant agrees by submitting this proposal that, should the proposed covered transaction be entered into, it shall not knowingly enter into any lower tier covered transaction with a person who is debarred, suspended, declared ineligible, or voluntarily excluded from participation in this covered transaction, unless authorized by the department or agency with which this transaction originated.
6. The prospective lower tier participant further agrees by submitting this proposal that it will include the clause titled "Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion -- Lower Tier Covered Transactions", without modification, in all lower tier covered transactions and in all solicitations for lower tier covered transactions.
7. A participant in a covered transaction may rely upon a certification of a prospective participant in a lower tier covered transaction that is not debarred, suspended, ineligible, or voluntarily excluded from the covered transaction, unless it knows that the certification is erroneous. A participant may decide the method and frequency by which it determines the eligibility of its principals. Each participant may check theSystem for Award Management (SAM).
8. Nothing contained in the foregoing shall be construed to require establishment of a system of records in order to render in good faith the certification required by this clause. The knowledge and information of a participant is not required to exceed that which is normally possessed by a prudent person in the ordinary course of business dealings.
9. Except for transactions authorized under paragraph 5 of these instructions, if a participant in a covered transaction knowingly enters into a lower tier covered transaction with a person who is suspended, debarred, ineligible, or voluntarily excluded from participation in this transaction, in addition to other remedies available to the Federal Government, the department or agency with which this transaction originated may pursue available remedies, including suspension and/or debarment.

Contractor Pay Request Certification

Project: _____

Locality: _____ **Contractor:** _____

Provisions: *The contractor hereby certifies that work completed on the above-referenced ARPA Project and Contract during the period for which payment is requested complies with the following required provisions, as applicable in accordance with the contract terms and conditions:*

1. **Contract Work Hours:** Each contractor is required to compute the wages of every mechanic and laborer on the basis of a standard work week of 40 hours. Work in excess of the standard work week is permissible provided that the worker is compensated at a rate of not less than one and a half times the basic rate of pay for all hours worked in excess of 40 hours in the work week. The requirements of the Contract Work Hours and Safety Standards Act, 40 USC 3702 and 3704, as supplemented by Department of Labor regulations at 29 CFR Part 5 are applicable to construction work and provide that no laborer or mechanic must be required to work in surroundings or under working conditions which are unsanitary, hazardous or dangerous. These requirements do not apply to the purchases of supplies or materials or articles ordinarily available on the open market, or contracts for transportation or transmission of intelligence.

2. **Safety Standards Act:** Safety Standards and Accident Prevention provisions require contractors to:
   - Comply with the safety standards provisions of applicable laws, building and construction codes, the "Manual of Accident Prevention in Construction" published by the Associated General Contractors of America, the requirements of the Occupational Safety and Health Act of 1970, and the requirements of Title 29, Section 1518.
   - Exercise every precaution at all times for the prevention of accidents and the protection of persons (including employees) and property.
   - Maintain at the construction office or other well-known place on the job site, all articles necessary for giving first aid to the injured and make standing arrangements for the immediate removal to a hospital or to a doctor's care those persons (including employees), who may be injured on the job site. In no case shall employees be permitted to work at a job site before the employer has made a standing arrangement for removal of injured persons to a hospital or doctor's care.

3. **Debarment and Suspension:** In accordance with 2 CFR Part 180 and Treasury's implementing regulations at 31 CFR Part 19, ARPA funds may not go to individuals or entities that are prohibited from doing business with the federal government. *Debarment status can be checked on the System for Award Management (SAM) website at www.sam.gov.*

CERTIFICATION:

- I certify to the best of my knowledge and belief, that the above referenced project has complied with the applicable provisions of the Contract Work Hours and Safety Standards Act as outlined above during the period for which payment is requested.
- I certify to the best of my knowledge and belief, that all laborers and mechanics employed by contractors and subcontractors during the period for which payment is requested were paid prevailing wages.
- I certify to the best of my knowledge and belief, that I nor my Company or any of my subcontractors on this project as included in the above-referenced Contract are not presently debarred, suspended, or ineligible from participating in transactions by the federal government or local government department or agency.
- I understand that a false statement on this certification shall be regarded as a material breach of the Agreement. I also acknowledge that state agencies or the US Treasury may request any additional information or documentation it deems necessary to demonstrate compliance in the form of an audit or otherwise pursuant to its ability to effectively administer these funds.

This form must be signed by the contractor and submitted as part of every Contractor's Application for Payment involving federal funds as supporting documentation. This form certifies compliance for the period as stated on the Contractor's Application for Payment.

Contractor Signature: _____ **Contractor Printed Name:** _____ **Date:** _____

"General Decision Number: SC20230031 03/17/2023

Superseded General Decision Number: SC20220031

State: South Carolina

Construction Type: Building

County: York County in South Carolina.

BUILDING CONSTRUCTION PROJECTS (does not include single family homes or apartments up to and including 4 stories).

Note: Contracts subject to the Davis-Bacon Act are generally required to pay at least the applicable minimum wage rate required under Executive Order 14026 or Executive Order 13658. Please note that these Executive Orders apply to covered contracts entered into by the federal government that are subject to the Davis-Bacon Act itself, but do not apply to contracts subject only to the Davis-Bacon Related Acts, including those set forth at 29 CFR 5.1(a)(2)-(60).

If the contract is entered into on or after January 30, 2022, or the contract is renewed or extended (e.g., an option is exercised) on or after January 30, 2022:	. Executive Order 14026 generally applies to the contract. . The contractor must pay all covered workers at least $16.20 per hour (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract in 2023.
If the contract was awarded on or between January 1, 2015 and January 29, 2022, and the contract is not renewed or extended on or after January 30, 2022:	. Executive Order 13658 generally applies to the contract. . The contractor must pay all covered workers at least $12.15 per hour (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on that contract in 2023.

The applicable Executive Order minimum wage rate will be

adjusted annually. If this contract is covered by one of the Executive Orders and a classification considered necessary for performance of work on the contract does not appear on this wage determination, the contractor must still submit a conformance request.

Additional information on contractor requirements and worker protections under the Executive Orders is available at http://www.dol.gov/whd/govcontracts.

Modification Number	Publication Date
0	01/06/2023
1	03/17/2023

* ELEC0379-010 09/05/2022

	Rates	Fringes
ELECTRICIAN	$ 30.28	15.5%+8.35

Work from swinging scaffolds, boson chairs, or raw structural steel: $1.00 per hour additional.

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* SUSC2011-027 08/31/2011

	Rates	Fringes
BRICKLAYER	$ 17.50	0.67
CARPENTER (Form Work Only)	$ 15.53 **	1.76
CARPENTER, Excludes Drywall Hanging, and Form Work	$ 17.14	0.00
CEMENT MASON/CONCRETE FINISHER	$ 14.10 **	0.00
DRYWALL HANGER	$ 16.32	1.50
LABORER: Common or General	$ 11.26 **	0.00
LABORER: Landscape	$ 9.45 **	0.49
LABORER: Mason Tender-Brick/Concrete/Cement/Stone	$ 10.88 **	0.00
LABORER: Pipelayer	$ 14.69 **	2.08

OPERATOR:
Backhoe/Excavator/Trackhoe.....$ 16.05 ** 1.96

OPERATOR: Bulldozer.....$ 17.07 2.65

OPERATOR: Crane.....$ 19.39 2.02

OPERATOR: Grader/Blade.....$ 17.50 1.78

OPERATOR: Loader.....$ 11.64 ** 1.03

PAINTER: Brush, Roller and
Spray.....$ 12.36 ** 0.00

PIPEFITTER.....$ 19.67 9.16

PLUMBER.....$ 19.21 4.56

ROOFER.....$ 12.11 ** 0.00

SHEET METAL WORKER (HVAC Duct
Installation Only).....$ 19.11 0.00

TRUCK DRIVER.....$ 14.05 ** 3.18

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

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** Workers in this classification may be entitled to a higher minimum wage under Executive Order 14026 ($16.20) or 13658 ($12.15). Please see the Note at the top of the wage determination for more information.

Note: Executive Order (EO) 13706, Establishing Paid Sick Leave for Federal Contractors applies to all contracts subject to the Davis-Bacon Act for which the contract is awarded (and any solicitation was issued) on or after January 1, 2017. If this contract is covered by the EO, the contractor must provide employees with 1 hour of paid sick leave for every 30 hours they work, up to 56 hours of paid sick leave each year. Employees must be permitted to use paid sick leave for their own illness, injury or other health-related needs, including preventive care; to assist a family member (or person who is like family to the employee) who is ill, injured, or has other health-related needs, including preventive care; or for reasons resulting from, or to assist a family member (or person who is like family to the employee) who is a victim of, domestic

violence, sexual assault, or stalking. Additional information on contractor requirements and worker protections under the EO is available at https://www.dol.gov/agencies/whd/government-contracts.

Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of ""identifiers"" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than ""SU"" or ""UAVG"" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate changes in the collective bargaining agreement (CBA) governing this classification and rate.

Survey Rate Identifiers

Classifications listed under the ""SU"" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all

rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour National Office because National Office has responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described

in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISIO"

SECTION 010100
SUMMARY OF THE WORK

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

1.01 LOCATION OF SITE: 149 W. Black St., Rock Hill, SC 29730

1.02 SUMMARY OF THE WORK:

A. The work described in the Contract Documents, Base Bid, includes the furnishing of all labor, materials, equipment, and services necessary to complete the following:

1. Remove and dispose existing roof top air handling units, split-system units and associated air distribution.

2. Remove and dispose of existing computer room air conditioning units.

3. Installation of variable refrigerant flow systems and air distribution.

4. Installation of new computer room air conditioning units.

5. Installation of new Building Automation System.

6. Remove and dispose of existing ceiling grid and tiles.

7. Installation of new ceiling grid and tiles.

8. Remove and dispose of existing fluorescent lighting.

9. Installation of new LED lighting.

1.03 CONTRACTORS USE OF PREMISES:

A. General: The Contractor shall limit their use of the premises to construction activities in areas indicated; allow for Owner occupancy and use of areas that are not within the construction activities.

B. Use of Existing Building: Protect and maintain existing walkways, roofs, and equipment and parking lot facilities throughout the construction period. Repair damage caused by construction operations. Take all precautions necessary to protect the building and occupants during the construction period.

1.04 OWNER OCCUPANCY: The Owners/Employees will occupy the site and continue daily activities during the construction period. Cooperate with the Owner and project

liaison during construction operations to minimize conflicts and facilitate Owner usage. Perform the work so as not to interfere with the Owner use except as permitted for specific components of the work.

1.05 COORDINATION ISSUES: The Contractor shall coordinate with the schedule of work and work activities, the Owners and their representatives. These schedules shall be updated at periodic coordination meetings at the site.

1.06 STAGING AREA AND FIELD OFFICE:

A. Material Storage: Construction materials may be stored on the construction site (in accordance with manufacturer's recommendations), and shall not be placed to block or cause a hazard to pedestrian or vehicular traffic. Storage shall be in the staging area designated in the Preconstruction Conference unless otherwise approved by the Owner in writing.

B. The Contractor shall not wash debris including cementitious residue from tools and equipment into the storm sewer system, onto the grounds or onto the adjacent property.

1.07 TEMPORARY WATER AND ELECTRICITY: Water and electric utilities shall be accessible to the Contractor at the project site.

1.08 TEMPORARY TOILET FACILITIES: The Owner’s restrooms and other facilities shall not be used by any personnel involved in the work at this job. The Contractor shall provide for all construction personnel all sanitary conveniences and water as required by public authorities having jurisdiction over such matters and in accordance with the General Conditions.

1.09 PARKING: The Contractor shall use parking areas designated by the Owner for parking during the construction.

1.10 PROTECTION: Protection shall consist (in general) of the following:

A. Streets and Walks: Contractor shall protect all streets, parking areas and walks, and shall make all necessary repairs at his own expense.

B. Private Roads, Entrances, and Walks: Contractor shall protect private roads, entrances, and walks. He shall maintain them during course of work, and shall repair all damages to same at his own expense.

C. Buildings and Equipment: The Contractor shall protect all existing buildings and equipment and shall repair all damages to same at his own expense.

1.11 SAFETY:

A. The Contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the work. The Contractor shall comply with all safety and other applicable requirements in regard to all phases of this project including but not limited to all applicable regulations of OSHA and EPA. The Contractor shall handle all products with

appropriate precautions and care as stated on the Material Safety Data Sheets (MSDS) for each product.

B. The Contractor shall be responsible for preventing access to construction equipment, tools and materials that may be hazardous, misused or stolen.

1.12 CONTRACTOR'S SUPERVISION: The Contractor shall assign and maintain a single person as "job superintendent" on this project.

END OF SECTION

SECTION 010270
PAYMENT PROCEDURES

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 FORM OF SUBMITTAL: Prepare Application for Payment using AIA Document G-702, "Project Application and Project Certification for Payment" supported by AIA Document G-703, "Continuation Sheet". List approved Change Orders separately on each Application for Payment reflecting any increase or decrease in the cost of the work for the project, as the case may be.

1.02 Schedule of Values

2. GENERAL:

   A. Related requirements specified elsewhere:

      1. Scheduling and Sequencing
      2. Submittals
      3. Product Substitutions
      4. Construction Schedules

   B. Submit Schedule of Values to the Engineer, at least ten (10) days prior to submitting first Application for Payment.

   C. Upon request by Engineer, support values given with data that will substantiate their correctness.

   D. List quantities of materials specified under unit price allowances.

   E. Use Schedule of Values only as basis for Contractor's Applications for Payment.

3. FORM OF SUBMITTAL:

   A. Submit on AIA Document G-703 "Continuation Sheet", latest edition, or other approved Format acceptable to the Engineer.

   B. Use table of contents of this specification as basis for format for listing costs of work for sections under Divisions 2 - 16. Additional breakdown of the work in certain sections may also be provided.

   C. Identify each line item with number and title as listed in table of contents of this specification.

4. PREPARING SCHEDULE OF VALUES:

A. Itemize separate line item cost for each of following general cost items:

1. Performance and Payment Bonds.
2. Field Supervision and Layout.
3. Temporary Facilities and Controls.

B. Itemize separate line item cost for work required by each section of this specification including General Conditions of the Contract.

C. Break down installed costs into:

1. Cost of component products, delivered and unloaded at job site. (List under Column F, G-703).

2. Total installed cost, with overhead and profit. (List under Column C, G-703).

D. For each line item which has installed value of more than $10,000.00, break down costs to list major products or operations under each item.

E. Round off figures to nearest $1.00.

F. Make sum of total costs of all items listed in schedule equal to total Contract sum.

5. REVIEW AND RESUBMITTAL:

A. After review by Engineer, revise and re-submit Schedule (and Schedule of Material Values) as required.

B. Re-submit revised Schedule in same manner.

END OF SECTION

SECTION 013400
SUBMITTALS

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, Division 1 Specification Sections, apply to work of this Section.

1.01 SECTION INCLUDES:

A. Requirements for submittals.

B. Submittal procedures for shop drawings, product data, and samples.

1.02 RELATED REQUIREMENTS:

A. Definitions and additional responsibilities of parties (General Conditions).

B. Requirements of individual sections of Specifications.

1.03 SHOP DRAWINGS:

A. Present in a clear and thorough manner. Title each drawing with project name and number; identify each element of Drawings by reference to sheet number and detail.

B. Identify field dimensions; show relation to adjacent or critical features of work or products.

C. Drawing Size: Minimum 18" x 24; Maximum 24" x 36.

1.04 PRODUCT DATA:

A. Submit only pages which are pertinent; mark each copy of manufacturer's printed data to identify pertinent products, referenced to applicable specification section and item number.

B. Modify manufacturer's standard drawings and information in order to provide information specifically applicable to the work of this Contract. Delete information not applicable.

C. Provide manufacturer's preparation, assembly, and installation instructions as specified.

D. Provide manufacturer's technical and performance data and agency approvals.

1.05 SAMPLES:

A. Submit samples to illustrate functional characteristics of products, including parts and attachments.

B. Required samples are indicated in the individual specification sections.

C. Samples shall be of sufficient size and quantity to clearly illustrate range of color, texture, pattern, and functional characteristics of products.

D. Label each sample to clearly identify material, function, and applicable specification section and item number.

1.06 CONTRACTOR REVIEW:

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

B. Coordinate submittals with requirements of work and of Contract Documents. All submittals shall be transmitted in ample time to prevent delays in the work.

C. Sign or initial each sheet of shop drawings and product data, and label each sample to certify compliance with requirements of Contract Documents. Notify Project Manager in writing at time of submittal of any deviations from requirements of Contract Documents.

D. Do not fabricate products or begin work which requires submittal until return of submittal with Project Manager acceptance.

1.07 SUBMITTAL REQUIREMENTS:

A. Submit to Project Manager or his representative as designated by the Project Manager.

B. Transmit submittals in accordance with approved progress schedule and in such sequence to avoid delay in the work or work of other contracts or sections.

C. Provide 6" x 6" blank space on each submittal for Contractor and Project Manager stamps.

D. Apply Contractor's stamp, signed or initialed, certifying to review and verification of products, field measurements, field construction criteria, and conformance with requirements of work and Contract Documents.

E. Coordinate submittals into logical groupings to facilitate interrelation of several items.

F. Number of submittals required:

1. Shop Drawings: Submit one (1) in PDF format.

2. Product Data: Submit in PDF format.

3. Samples: Submit the number required in each section of Specifications, but in no case less than two (2). Submit applicable product data with samples.

G. Submittals shall contain:

1. The date of submission and the dates of any previous submissions.

2. The project title and number.

3. Contract identification:

    a. Contractor
    b. Supplier
    c. Manufacturer

4. Identification of the product with the applicable specification section and item number.

5. Field dimensions, clearly identified as such.

6. Relation to adjacent or critical features of the work or materials.

7. Applicable standards, such as ASTM or Federal Specification numbers.

8. Identification of deviations from Contract Documents.

9. Identification of revisions on resubmittals.

10. Contractor's stamp "For Approval Only" (all submittals).

11. Contractor's stamp certifying review of submittal (Product Data and Samples).

12. Contractor's stamp "approved by Contractor" (Shop Drawings).

1.08 RESUBMITTALS:

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

B. Shop Drawings, Product Data:

1. Revise initial drawings or data, and resubmit as specified for the initial submittal.

2. Clearly indicate any changes which have been made.

3. When stamped for construction, submit two (2) reproducibles of shop drawings to the Construction Manager.

C. Samples: Submit new samples, as specified for the initial submittal.

1.09 PROJECT MANAGER DUTIES:

A. Review submittals with reasonable promptness and in accordance with schedule.

B. Affix stamp and initials or signature, and indicate requirements for resubmittal, or approval of submittal.

C. Return submittals to Contractor for distribution or for resubmission.

D. Project Manager may designate submittal review to the Engineer or to a representative of the Project Manager.

1.10 CONSIDERATION OF SUBSTITUTIONS:

A. Substitutions for specified products will be considered only if the specified product is not obtainable; or if delivery date of specified product is such that scheduled date of substantial completion of the Work will be delayed if the specified product remains a requirement; or if, after an order has been placed, circumstances beyond the Contractor's control, such as labor disputes affecting manufacture or delivery of product cause such a delay; or for any other reason the Owner agrees the substitution may be in his best interest.

B. Qualifications: Substitutions will not be considered if:

1. They are indicated or implied on shop-drawing submittals without having been formally requested in accordance with provisions specified herein.

2. For their implementation, they require a major revision in the Work in order that their use may be accommodated.

3. They materially alter the design concept, including color or function originally intended by the specified product.

4. They do not meet all of the physical and performance requirements contained in the Project Specifications for the specified product.

5. They do not equal or exceed the product specifications for the specified product.

1.11 CONTRACTOR'S REPRESENTATION:

A. By submitting the Request for Substitution, the Contractor represents that he:

1. Has investigated the proposed substitute product, and

2. Has determined, by his best judgment and experience, that the proposed substitution is either necessary or in the Owner's best interest.

3. Will coordinate the installation of the accepted substitution, making such changes as may be required for the Work to be complete in all respects.

1.12 SUBMISSION PROCEDURES ON SUBSTITUTIONS:

A. State reason for making the request.

B. Identify product for which substitution is proposed by brand name and catalog number, giving Specifications Section and Article number where specified.

C. Identify, in similar manner, proposed substitution.

D. Itemize differences between product specified and proposed substitution, including, but not limited to, physical, color, function and guarantee considerations.

E. Itemize changes in adjacent work occasioned by proposed substitutions.

F. Accompany request with test data from independent laboratory substantiating quality and performance of proposed substitution.

G. Attach manufacturer's complete instructions on storage, handling and installation.

H. State proposed change to the Contract Sum and proposed change to the Contract Time if substitution is accepted and confirmed by Change Order. If the proposed substitution involves a change to the Contract Sum, any change in cost of adjacent or related work shall be included also.

I. State the number of days (not less than 15) during which the substitution as submitted is subjected to acceptance.

1.13 ACCEPTANCE OR REJECTION:

A. The Engineer will promptly review requests for substitutions complying with the above provisions.

B. If no exceptions are taken, the substitution will be confirmed by Bulletin and a subsequent Change Order.

C. If rejected, the Contractor will be promptly notified, and the Contractor shall proceed with the Work in accordance with the Contract Documents.

1.14 SUBSTITUTIONS:

A. Prior to commencing work, the Project Manager will consider requests from the Contractor for substitutions. Substitutions will then be considered only when a product becomes unavailable due to no fault of the Contractor, or is approved as Equal to the specified product by the Designer.

B. Document each request with complete data substantiating compliance of proposed substitution with Specifications.

C. A substitution request constitutes a representation that the Contractor:

1. Has investigated the proposed product and determined that it meets or exceeds, in all respects, specified product.

2. Shall provide the same warranty for substitution as for specified product.

3. Shall coordinate installation and make other changes which may be required for work to be complete in all respects.

4. Waives claims for additional costs which may consequently become apparent.

D. Substitutions will not be considered when they are indicated or implied on Shop Drawings or Product Data submittals without separate written request, or when acceptance will require substantial revision of Contract Documents.

E. The Engineer will determine acceptability of proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.

END OF SECTION

SECTION 015000
CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 UTILITIES:

A. Provide utility services required for construction operations.

1.02 VENTILATION:

A. Provide, as required, facilities to maintain specific storage conditions as described within this specification.

B. Provide adequate ventilation of enclosed areas to prevent the accumulation of fumes, vapors, and gases.

C. Existing facilities may not be used for storage during construction.

1.03 SANITARY FACILITIES:

A. Provide and maintain required facilities and enclosures.

B. Owner's existing facilities shall not be used.

1.04 CLEANING DURING CONSTRUCTION: Demolition debris from construction operations shall not be allowed to accumulate and shall be removed from the site and disposed of daily, unless prior arrangement is made with the Owner.

1.05 REMOVAL: Provide removal services and coordinate placement and servicing of trucks or containers with the Owner. Existing facilities and services shall not be used.

1.06 PROTECTION OF FACILITIES:

A. The Contractor shall be responsible for guarding against fires and shall provide suitable and adequate fire extinguishers conveniently located at the site. Competent operators shall be in attendance at all times equipment is subject to use.

B. The Contractor is responsible for providing all necessary chutes, tarps, or other measures required to protect the walls, sidewalks, streets, parking areas and other work from damage, soiling, staining, etc., that could result from construction activity of this Contract. Any damage caused by construction activity shall be repaired by the Contractor at his own expense.

C. The Contractor shall fine grade any lawn area which is disturbed and shall reseed after work is complete.

D. Telephone numbers shall be given to the Project Manager for contacting the Superintendent and Foreman during off hours and weekends.

END OF SECTION

SECTION 015600
CLEANING UP

PART 1 - GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, Division 1 Specification Sections, apply to work of this Section.

1.01 REMOVAL OF DEBRIS:

A. All debris and waste materials shall become the property of the Contractor and the Contractor shall be responsible for removal of the debris from the project site on a daily basis or as approved by the Owner.

B. Demolition debris shall be removed in covered trucks or other method that prevents debris, litter, dust, etc. from falling onto streets, sidewalks or soil. Streets, sidewalks and other public and private spaces shall be kept clean and free from demolition debris at all times.

C. The Contractor shall be responsible for the cleanup of streets, driveways, sidewalks and landscaping. Failure to clean promptly (within one day's notice) will result in the Owner having areas cleaned and deducting costs for same from the Contractor's contract.

D. No storage of debris or trash will be allowed on the site.

1.02 DUST AND DEBRIS:

A. The Contractor shall not allow debris and dust to accumulate for more than one day before removing such from adjacent public streets and driveways as a result of the work of this project. At no time shall any accumulation be allowed which will create a hazard to safety or which will create bad public relations.

B. The measures to be used to prevent littering the pavement shall include (but does not constitute the only measure to be used, if necessary) the following:

1. Pick up droppings as they occur.

1.03 CLEANING UP: Before final inspection and acceptance of the project, clean work under the contract.

END OF SECTION

SECTION 016000
MATERIALS AND EQUIPMENT

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 PRODUCTS:

A. Products include materials, equipment and systems.

B. Comply with Contract Documents and referenced standards as minimum requirements.

C. Do not use or remove from site any materials and equipment removed from the existing structure, except as specifically required or allowed by Contract Documents.

D. All construction procedures and materials used in the work for this project shall comply with the following:

1. Contract Documents

2. Applicable Manufacturer's Specifications

3. Accepted standards/practices

4. Applicable building codes, both national and local

1.02 WORKMANSHIP:

A. Work shall be performed by persons qualified to produce workmanship and quality specified.

B. The Contractor's designated Superintendent shall provide full-time on-site supervision.

1.03 MANUFACTURER'S INSTRUCTIONS:

A. Work shall be performed in accordance with the Material Manufacturer's specifications as modified by the Contract Documents.

B. Conflicts between the Contract Documents and the Material Manufacturer's specifications shall be brought to the attention of the Project Manager prior to beginning construction. Work in this area shall not proceed until conflicts are satisfactorily resolved by Project Manager.

C. Provide Material Safety Data Sheets (MSDS) for all materials brought on the site.

1.04 TRANSPORTATION AND HANDLING:

A. Transport products by methods to avoid product damage; deliver all materials with Manufacturer's labels intact and legible.

B. Provide equipment and personnel to handle products by methods to prevent damage.

1.05 STORAGE AND PROTECTION:

A. The following are considered minimum requirements. Additional storage and protection requirements are specified in individual sections of the specifications.

B. Store all materials so as to maintain clean, dry, weathertight conditions and to protect against loss, damage, and wetting. Wet materials and/or materials indicating moisture contents above equilibrium shall be marked, rejected for installation, and removed from the site.

C. Materials temporarily stored on the roof shall be located in approved areas and shall be distributed in such a manner as to stay within the load limits of the roof construction.

D. Materials subject to moisture intrusion and damage shall be stored on clean, dry, and raised platforms so as to prevent wetting or moisture absorption and yet provide sufficient ventilation to prevent condensation. These materials shall be covered so as to be completely weathertight. Factory-applied wrapping shall be unacceptable as the sole means of protection.

E. Any materials which when subject to moisture intrusion may have a detrimental effect on the installation or performance of other components of the installed systems shall be stored as indicated in Items 1.05, B. and D.

1.06 PRODUCT OPTIONS:

A. The Contractor shall submit list of materials proposed in accordance with Section 01340.

B. Contractor Product Selection:

1. Products specified only by referenced standards: Any product meeting that standard.

2. Products specified by naming several manufacturers: Products of any named manufacturer meeting Specifications.

3. Products specified by naming one or more manufacturers and "or as approved": Submit a request for substitution in accordance with Item 1.07 of this section.

4. Products specified by naming only one (1) product or Manufacturer: There is no option and no substitutions will be allowed.

1.07 SUBSTITUTIONS:

A. Prior to commencing work, the Project Manager will consider requests from the Contractor for substitutions. Substitutions will then be considered only when a product becomes unavailable due to no fault of the Contractor, or is approved as Equal to the specified product by the Designer.

B. Document each request with complete data substantiating compliance of proposed substitution with Specifications.

C. A substitution request constitutes a representation that the Contractor:

1. Has investigated the proposed product and determined that it meets or exceeds, in all respects, specified product.

2. Shall provide the same warranty for substitution as for specified product.

3. Shall coordinate installation and make other changes which may be required for work to be complete in all respects.

4. Waives claims for additional costs which may consequently become apparent.

D. Substitutions will not be considered when they are indicated or implied on Shop Drawings or Product Data submittals without separate written request, or when acceptance will require substantial revision of Contract Documents.

E. The Project Manager will determine acceptability of proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.

END OF SECTION

SECTION 017000
CONTRACT CLOSE-OUT

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 CLOSE-OUT PROCEDURES:

A. Conduct a final inspection at completion of piping and equipment installation, Owner, Inspection Representative, Project Manager.

B. The results of the inspection conducted by these parties shall be submitted in writing to the Project Manager.

C. Contractor shall remedy any and all deficiencies prior to final acceptance by the Project Manager.

1.02 FINAL CLEANING:

A. Execute cleaning prior to final inspection.

B. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.03 PROJECT RECORD DOCUMENTS: Submit "as built" documents with letter of transmittal indicating date, project number, Contractor's name and address, list of documents, and signature of Contractor.

1.04 GUARANTY/WARRANTY:

A. Provide guaranty/warranty properly executed in triplicate.

B. Guaranty/warranty shall state name of project, location, name of Owner, name of Contractor and Manufacturer, and date of final acceptance. Date of final acceptance will be as determined by the Project Manager for the entire system.

END OF SECTION

SECTION 017200
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.02 MAINTENANCE OF DOCUMENTS:

A. Maintain at job site, one copy of:

1. Contract Drawings
2. Specifications
3. Addenda
4. Bulletins
5. Reviewed Shop Drawings indicating "No Exceptions Taken" or "Make Correction Noted"
6. Change Orders
7. Other Modifications to Contract
8. Field Test Records

B. Store documents in temporary field office, apart from documents used for construction. Do not use record documents for construction purposes.

C. Provide files and racks for storage of documents.

D. Maintain documents in clean, dry, legible condition.

E. Make documents available at all times for review by Engineer and Owner.

1.03 MARKING DEVICES: Provide colored pencils for marking.

1.04 RECORDING:

A. Label each document "PROJECT RECORD" in minimum 2 in. high printed letters.

B. Keep record documents current.

C. Do not permanently conceal any work until required information has been recorded.

D. Contract Drawings: Legibly mark to record actual construction:

1. Location of internal utilities and appurtenances concealed in construction referenced to visible and accessible features of structure.

2. Field change of dimension and detail.

3. Changes made by Change Order or Field Order.

4. Details not on original Contract Drawings.

E. Specifications and Addenda: Legibly mark up each section to record:

1. Manufacturer, trade name, catalog number, and Supplier of each product and item of equipment actually installed.

2. Changes made by Change Order or Field Order.

3. Other matters not originally specified.

F. Shop Drawings: Maintain as record documents; legibly annotate drawings to record changes made after review:

1.05 SUBMITTAL:

A. At completion of project, deliver record documents to Engineer.

B. Accompany submittal with transmittal letter, in duplicate, containing:

1. Date
2. Project title and number
3. Contractor's name and address
4. Title and number of each record document
5. Certification that each document as submitted is complete and accurate.
6. Signature of Contractor, or his authorized representative.

END OF SECTION

SECTION 09 51 23
ACOUSTICAL TILE CEILINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Acoustical tiles.
2. Metal suspension system.
3. Accessories.
4. Metal edge moldings and trim.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Acoustical tiles.
2. Metal suspension system.
3. Accessories.
4. Metal edge moldings and trim.

B. Samples: For each exposed product and for each color and texture specified, 6 inches in size.

1.03 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size tiles equal to 2 percent of quantity installed.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical tiles, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical tiles, permit them to reach room temperature and a stabilized moisture content.

1.06 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical tile ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical tile ceiling installation.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Source Limitations for Suspended Acoustical Tile Ceiling System: Obtain each type of acoustical ceiling tile and its suspension system from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Class A in accordance with ASTM E1264.
2. Smoke-Developed Index: 50 or less.

2.03 ACOUSTICAL TILES

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

1. Armstrong World Industries, Inc.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Acoustical Tile Standard: Provide manufacturer's standard tiles of configuration indicated that comply with ASTM E1264 classifications as designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Classification: Provide tiles as follows:

1. Type and Form, Type IV: Mineral base with membrane-faced overlay; Form 1, nodular Form 2, water felted.
2. Pattern: E (lightly textured).

D. Color: White.

E. Ceiling Attenuation Class (CAC): Not less than 35.

F. Edge/Joint Detail: Beveled, kerfed, and rabbeted.

G. Thickness: 3/4 inch.

H. Modular Size: As indicated on Drawings.

I. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.

2.04 METAL SUSPENSION SYSTEM

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

1. Armstrong Ceiling & Wall Solutions.
2. USG Corporation.
3. CertainTeed; SAINT-GOBAIN.

B. Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, fully concealed, metal suspension system and accessories of type, structural classification, and finish indicated that complies with applicable requirements in ASTM C635/C635M.

2.05 ACCESSORIES

A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.

B. Wire Hangers, Braces, and Ties: Provide wires as follows:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch- diameter wire.

2.06 METAL EDGE MOLDINGS AND TRIM

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

1. Armstrong World Industries, Inc.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations complying with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for of suspension-system runners.

1. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.
2. Finish: Painted white.

C. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements.

1. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
2. Baked-Enamel or Powder-Coat Finish: Minimum dry film thickness of 1.5 mils. Comply with ASTM C635/C635M and coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing and substrates to which acoustical tile ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine acoustical tiles before installation. Reject acoustical tiles that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Measure each ceiling area and establish layout of acoustical tiles to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width tiles at

borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.

B. Layout openings for penetrations centered on the penetrating items.

3.03 INSTALLATION OF SUSPENDED ACOUSTICAL TILE CEILINGS

A. Install suspended acoustical tile ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
3. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
4. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
5. Do not use exposed fasteners, including pop rivets, on moldings and trim.

C. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

D. Arrange directionally patterned acoustical tiles as follows:

1. As indicated on reflected ceiling plans.

E. Install acoustical tiles in coordination with suspension system and exposed moldings and trim. Place splines or suspension-system flanges into kerfed edges of tiles so tile-to-tile joints are interlocked.

1. Fit adjoining tiles to form flush, tight joints. Scribe and cut tiles for accurate fit at borders and around penetrations through ceiling.
2. Hold tile field in compression by inserting leaf-type, spring-steel spacers between tiles and moldings, spaced 12 inches o.c.

3.04 ADJUSTING

A. Clean exposed surfaces of acoustical tile ceilings, including trim and edge moldings. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.

B. Remove and replace tiles and other ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 23 00 10
MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

A. The Contract Documents apply to this section.

B. The term "Contractor" and "Mechanical Contractor" referred to in Division 23 Specifications shall be interchangeable and shall be designated as the Mechanical Contractor assigned to work specified in Division 23.

1.2 REFERENCES

A.	Air Conditioning and Refrigeration Institute	ARI
B.	American National Standards Institute	ANSI
C.	Air Moving and Conditioning Association	AMCA
D.	American Petroleum Institute	API
E.	American Society for Testing and Materials	ASTM
F.	American Society of Heating, Refrigeration & Air Conditioning Engineers	ASHRAE
G.	American Society of Mechanical Engineers	ASME
H.	American Welding Society	AWS
I.	Anti-Friction Bearing Manufacturers Association	AFBMA
J.	Commercial Standards	CS
K.	Factory Mutual Corporation	FMC
L.	Institute of Boiler and Radiator Manufacturers	IBR
M.	Industrial Risk Insurers	IRI
N.	Manufacturers' Standardization Society of the Valve & Fittings Industry (Standard Practice)	MSS SP
O.	National Electrical Code (NFPA 70)	NEC
P.	National Electrical Manufacturer's Association	NEMA
Q.	National Fire Protection Association	NFPA
R.	Sheet Metal & Air Conditioning Contractors National Association	SMACNA
S.	Steel Structures Painting Council	SSPC
T.	Underwriters Laboratories	UL
U.	United States Standard	USS

1.3 CODES, REGULATIONS, TAXES, PERMITS & FEES

A. Work under this Division shall meet the applicable requirements of the following codes and standards:

1. Federal laws and regulations
2. South Carolina State Building Code, all volumes and parts
3. Local Authority Having Jurisdiction

B. Applicable code requirements shall govern where code requirements exceed the requirement of the Drawings and Specifications. The Drawings and

Specifications shall govern where the work and materials specified exceed applicable code requirements.

C. The Contractor shall give all necessary notices, obtain all permits and pay all sales taxes, fees and other costs, including utility connections or extensions, in connection with his work; file all necessary plans, prepare all documents and obtain and coordinate all necessary approvals of all authorities having jurisdiction; and deliver these to the Engineer before request for acceptance and final payment of the work.

D. The Contractor shall include in his work, without extra cost to the Owner, any labor, materials, service, apparatus, drawings, and the like, required in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on Drawings and/or specified.

E. All materials furnished, and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, Underwriters' Laboratories, and with the requirements of all governmental departments having jurisdiction.

F. All materials and equipment for the electrical portion of systems shall bear the U.L. label, and shall be listed by the Underwriters' Laboratories, Inc.

G. All materials and equipment furnished under this Division shall be asbestos free.

1.4 EXAMINATION OF WORK SITE

A. Contractor and subcontractors shall, before submitting proposals, inform themselves of the conditions under which the work is to be performed, concerning the site of the work, the structure of the building, the obstacles which may be encountered, and all other relevant matters concerning the work to be performed.

B. No extra compensation will be allowed for failure to secure such information which was available prior to bidding. No extras will be allowed because of additional work necessitated by, or change in plans required because of, evident job conditions that are not indicated on the Drawings.

1.5 PROJECT SCHEDULE: Contractor and subcontractors shall, before submitting proposals, inform themselves of the Project Schedule, phase requirements, and complexities associated with the construction of the work under this contract. The Contractor shall assess all pertinent aspects of manpower requirements, coordination, supervision, scheduling, mobilization, equipment procurement, start-up, test and balance, demands of construction project management, and the like, to assure proper planning to meet the Project Schedule.

1.6 DRAWINGS AND SPECIFICATIONS

A. Contractor is cautioned to read the entire Contract Specifications and the entire set of Contract Drawings to assure that no reference to work by the Contractor is overlooked and to assure an understanding of the division of work between the various trades and/or contracts. Failure of the Contractor to do this shall not relieve him of any responsibility or remove any work from the contract.

B. The general arrangement of ductwork, piping and equipment shall be as shown on the Drawings. Detailed drawings of proposed departures due to actual field conditions or other causes shall be submitted to the Engineer for approval prior to installation. Any such changes shall be made without additional cost to the Owner. The Contractor shall examine carefully all Contract Documents, and shall be responsible for the proper fitting of materials and equipment in each location as indicated, without substantial alteration.

C. The Drawings are generally diagrammatic and may not indicate all off-sets, fittings, and accessories which may be required. The Contractor shall investigate all potential obstructions carefully, plan ahead, and provide at no additional cost to the Owner such fittings, valves, transitions and accessories as may be required to meet such conditions.

D. The right to make any responsible change in location of apparatus, equipment, and/or routing of piping or ductwork, up to the time of roughing in, without involving any additional expense to the Owner, is reserved by the Engineer.

E. Design is based on equipment indicated on Drawings, Schedules, and Specifications. Where the Contractor provides equipment different from equipment indicated in these documents, Contractor shall be responsible for and bear all cost for all changes to documentation, systems, and equipment required by furnishing this equipment

1.7 SUBMITTALS

A. Contractor shall submit within thirty (30) calendar days after award of contract, seven (7) copies of a complete list of products supplied by each manufacturer to be used on the job. No substitutions will be allowed after this date except in extenuating circumstances with approval of the Engineer. Use of a manufacturer's name or equipment number in these Specifications or on the Drawings shall not be considered as equipment approval by the Engineer without confirming shop drawing submittal and approval.

1.8 COORDINATION DRAWINGS

A. Coordination drawings specified in this section shall be prepared for mechanical equipment spaces, for equipment layout, fabrication, and installation of piping, ductwork, and the like. These drawings shall be prepared to coordinate clearances with other trades.

B. Coordination overlay drawings are required for each trade for all locations and shall be submitted as "shop drawings" for approval.

C. The Mechanical Contractor shall prepare complete computer generated coordination overlay drawings at a suitable scale not less that 1/4" = 1'-0" (Mechanical room coordination overlay drawings shall be ½" = 1'-0" scale). Each trade shall be responsible for providing an overly file of his work to the Mechanical Contractor. Drawings shall show each trades' work relative to the structural and architectural features of this facility and relative to other trades. Trade work shall include mechanical, plumbing, fire protection, electrical, telecommunications, and controls. The Engineer will provide AUTOCADD files of mechanical plans for the contractor's use. The coordination drawings when

completed shall have each contractor's approval stamp and signature indicating complete coordination between all trades. These drawings shall be submitted in the latest AUTOCADD format with each trade on a separate layer. No work shall begin nor shall any payment be provided until such time as the coordination shop drawings have been reviewed and approved by the Engineer.

D. If the Contractor installs work before coordination with other trades, he shall made the necessary changes in this work to correct interferences without extra charge to the Owner.

E. One complete set of approved coordination drawings shall be kept at the work site at all times, and shall be updated and maintained in the same manner as that required for Record Drawings. When specified herein, original tracings and/or CAD (computer-aided-drafting) drawings shall also be updated and maintained for submittal as part of Project Closeout.

1.10 SHOP DRAWINGS

A. Contractor shall submit for approval detail shop drawings of all equipment and materials listed in this section and in other Specification Sections. No materials or equipment required to be approved shall be delivered to the job site or installed until the Contractor has in his possession the approved shop drawings for the particular material or equipment. The submittals of shop drawings shall be completed as described herein. Submit the number of copies as indicated in Division 1.

B. Approval by the Engineer of shop drawings shall not be considered as a guarantee of quantities, measurements, or building conditions. Where drawings are provided, approval does not mean that drawings have been checked in detail. Approval does not in any way relieve the Contractor from his responsibilities or the necessity of furnishing material and performing work as required by the Contract Drawings and Specifications.

C. Shop drawings shall be submitted at least two weeks in advance to allow the Engineer ample time for review and approval. Submit for approval detailed, dimensioned drawings or catalog cuts, showing materials, finishes, construction, size, arrangement, operating clearances, performance characteristics, capacity, and the like. Each equipment submittal shall include manufacturer's installation instructions. Submittals which lack installation instructions shall be returned.

D. Written Description of Compliance Required:

1. Contractor shall prepare and submit a typewritten DESCRIPTION OF COMPLIANCE for each item in each shop drawing submittal. The DESCRIPTION OF COMPLIANCE shall follow the same format as the Contract Specifications. Every paragraph number used in the Specifications shall be used in the DESCRIPTION OF COMPLIANCE. A statement shall be written addressing each paragraph and requirement of the Specification.

2. The DESCRIPTION OF COMPLIANCE shall also address each line item of the Equipment Schedules on the Drawings, and the requirements of each note and detail on the Drawings.

3. Even if the Contractor believes the item being submitted complies exactly with the Specifications, the DESCRIPTION OF COMPLIANCE shall be prepared and included with the submittal. It often happens that the specified manufacturer and model number of an item are submitted, but available options and special requirements are not addressed, and the shop drawing must be returned for resubmittal. The requirement for a DESCRIPTION OF COMPLIANCE is intended to avoid this situation.

4. The Contractor shall itemize compliance for each Specification paragraph and requirements, for each line item of the schedule on the Drawings, and for each detail and note requirement on the Drawings, as follows:

   a. If the item being submitted for approval complies in <u>every detail,</u> write "Complies with Spec."

   b. If the item generally complies, but has certain exceptions, which the Contractor believes are minor or inconsequential, write "Complies with Exceptions." Write a description of each exception and describe why the Contractor believes the submittal should be approved.

   c. If the item does not comply, write "Does not comply." Then write a description of why the Contractor believes the item should be considered for approval, although it does not comply with the Specification. Regarding substitutions, refer to Substitutions and Product Options in Part 2 of this section.

   d. If the specific requirement does not apply to the item being submitted, write "Not Applicable." Then write a description of why the Contractor believes the requirement does not apply.

E. It is considered normal that some shop drawings may be required to be resubmitted to clarify or resolves some issues that are not clear or complete in the first submittal. However, when further resubmittal is necessary, after the first two (2) times of submittal for any shop drawing, to demonstrate complete compliance with the Contract Documents, it shall be considered indicative of inadequate review and preparation by the Contractor and his suppliers.

F. The time required for review and processing by the Engineer, after the first two (2) times of submittal of any shop drawing, shall be reimbursable to the Engineer, based on the Engineer's standard hourly billing rate schedule. Reimbursement shall be by the Owner to the Engineer, upon presentation of an invoice for this Additional Service. The Owner shall fund this reimbursement by a deduction from the Contractor's Contract Sum for this project.

G No payment for any material, equipment or labor will be approved until all required shop drawings for that material, equipment and labor have been approved by the Engineer.

H. Failure of the Contractor to submit shop drawings in ample time for review and approval shall not entitle him to an extension of contract time, and no claim for extension by reason of default will be allowed.

I. The Contractor shall be financially responsible for any price increase of shop drawing items from the time shop drawings are issued until they are returned to the Contractor for purchase of items.

J. Shop drawing samples, drawings, specifications, or catalogs submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, Contractor's name and name of job.

K. Identify each item submitted using applicable Tag Number, Specification section number or Drawing reference.

L. Catalogs, pamphlets, or other documents submitted to describe items for approval shall be specific. Items submitted shall be clearly marked. Data of a general nature will not be accepted. Data shall include copies of computation sheets indicating how unit capacity was determined where ratings are at other than standard conditions. Submit the same number of copies as required for shop drawings.

M. Shop Drawing Submittals Required:

1. Ductwork construction standards (Contractor's shop standards of fabrication)
2. Insulation - pipe, duct & equipment
3. Turning vanes
4. Grilles, registers, diffusers
5. Duct access doors, panels & test holes
6. Vibration isolation components
7. Pipe supports, hangers, and accessories
8. Mechanical identification for pipe, valves, ducts & equipment
9. Motors (furnish data along with the driven equipment)
10. Proposed Test and Balance Procedures
11. Piping materials, fittings, valves, and the like
12. Balancing dampers (rectangular and round)
13. Duct lining
14. Pressure gauges
15. Temperature gauges
16. Air handling units
17 Rooftop accessories (roof curbs, supports and the like)
18. Test readings (testing & balancing reports)
19. Controls system drawings, product cut sheets, sequence of operation (complete) for all systems (dampers, valves, devices, materials, etc.)
20. Other specific submittals as required by Specifications

1.11 COOPERATION

A. The Contractor shall give full cooperation to the Owner and other trades, and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

B. Where the work of the Contractor will be installed in close proximity to, or may interfere with work of the Owner or other trades, he shall assist in working out space conditions to make a satisfactory adjustment.

C. The successful Contractor shall employ, insofar as possible, such methods and means in the carrying out of this work as will not cause any interruption or interference with any separate Contractor or with Owner.

D. The Contractor shall furnish to other trades, as necessary for coordination, all templates, patterns, setting plans, shop details, and the like for the proper installation of work and for the purpose of coordinating adjacent work.

E. Piping, ductwork, and equipment to be concealed in walls, floors, and ceilings shall be installed before walls, floors, and ceilings are constructed.

F. Penetrations or openings required in walls, floors, ceilings, and roofs for piping, ductwork, equipment, or for any other reason, shall be sized, located and coordinated with other trades involved before construction of the walls, floors, ceilings and roofs.

1.12 COORDINATION - GENERAL

A. Temporary interruption of essential services or production may be allowed by the Owner during normal working hours. This possibility shall be scheduled in consultation with the Owner and shall not be of longer duration than essential to accomplish the purpose for such interruptions.

B. The Contractor shall obtain permits from the Owner for all welding or burning operations within the building(s) or above the roof of the building(s). The Contractor shall give such notice as will permit coordination of welding and burning operations with the Owner's activities and safety requirements. Approved mechanical igniters shall be used for burning and welding equipment.

C. Contractor shall perform only the specific work assignments set forth in the contract. In all other respects the Contractor and his employees, and his subcontractors shall observe the rights of the Owner to control and assign work not specifically described in this contract without interference or interruption from the Contractor, or his employees, or his subcontractors.

D. Contractor shall effect cooperation between his employees and those of Owner and Contractors on work awarded separately by the Owner, to the end that all work is properly anchored, installed and finished without hindrance or delay. Care shall be taken to avoid marring surfaces of the work of other Contractors, and each Contractor shall be held responsible for any damage to the work of others. Repair of new work shall be made by the original Contractor at the expense of the Contractor responsible for the damage.

E. Contractor shall obtain all necessary measurements of existing conditions and work by others in order that his work shall fit properly. No extra compensation will be allowed because of differences between actual dimensions and the measurements indicated on the Drawings.

1.13 COORDINATION OF INSTALLATION OF INSTRUMENTATION AND CONTROLS

A. The Mechanical Contractor shall coordinate with the Controls Subcontractor and the instrumentation and controls supplier regarding proper location and installation of sensing and control devices in piping, ductwork, and equipment.

The Controls Subcontractor shall be responsible for the sizing and selection of all sensors. The Controls Subcontractor shall also be responsible for providing instructions for the proper installation of his equipment, such as maintaining proper upstream and downstream straight-run dimensions on piping and ductwork to receive sensors.

B. The Mechanical Contractor shall be responsible for the final installation with regard to proper locations, workmanship and final insulation of equipment and systems in which the elements and controls are installed.

C. The Controls Subcontractor shall provide all electrical work required for the controls systems, as described in Section 23 09 00 and on the Drawings, all per the Electrical Specifications or specific installation requirements.

1.14 COORDINATION OF INSTALLATION OF FIRE SAFETY EQUIPMENT

A. The Mechanical Contractor shall coordinate with the Electrical Contractor, Fire Alarm Equipment Supplier, Instrumentation and Controls Supplier, and other as necessary regarding proper location and installation of sensing and control devices in ductwork and equipment.

B. Unless specified otherwise herein, the Electrical Contractor shall be responsible for the sizing and selection of all sensors, primary signaling devices and controls, such as, but not limited to, temperature sensors and ionization or smoke detectors. The Electrical Contractor, and his supplier, shall also be responsible for providing instructions for the proper installation of his equipment, such as maintaining proper upstream and downstream straight-run dimensions on ductwork to receive sensors.

C. The Mechanical Contractor shall install the primary sensing elements and controls provided by the Electrical Contractor. Installation of each item shall be as recommended by the Electrical Contractor. If his recommendation conflicts with or is substantially different from the Specifications and Drawings, the conflict or difference shall be resolved with the Engineer before proceeding.

D. The Mechanical Contractor shall be responsible for the final installation with regard to proper locations as required by the Electrical Contractor, workmanship and final insulation of equipment and systems in which the elements and controls are installed.

E. The Electrical Contractor shall be responsible for the installation and operation of the Fire Safety Systems complete, except as described above.

F. The Contractor is referred to the Instrumentation and Control Drawings and Specifications, and to Division 26, Electrical, for information.

1.15 INSPECTIONS

A. The Contractor shall be responsible for notifying and coordinating inspections with the authority having jurisdiction when work is ready for inspection. No work shall be covered or concealed until after inspection has been completed on such items as piping, ductwork, insulation, and the like.

B. The project will be observed by Engineer periodically as construction

progresses. The Contractor shall be responsible for notifying the Engineer at least 48 hours in advance when any work to be covered is ready for inspection. No work shall be covered or concealed until after observation and verification of testing has been completed on such items as piping, ductwork, insulation, and the like.

1.16 SYSTEM COMMISSIONING

A. Mechanical Contractor shall cooperate fully with the Engineer.

B. Provide assistance during commissioning as required to complete the commissioning procedures.

1.17 GUARANTEE

A. The Contractor shall guarantee the complete systems against defect due to faulty materials, faulty workmanship or failure due to negligence of the Contractor. This guarantee will exclude normal wear, maintenance, lubrication, replacement of expendable components, or abuse. During the guarantee period, the Contractor shall make good such defective workmanship and materials and any damage resulting from such defects within a reasonable time of notice given by the Owner.

B. The period of Guarantee for all materials, labor and equipment shall be 12 months from the date of final acceptance of the work unless noted otherwise. The period of guarantee on the affected equipment and systems shall be extended as necessary to provide one full season of operation of the cooling systems and of the heating systems.

C. Where items of equipment or material carry a manufacturer's warranty for a period in excess of twelve (12) months, the manufacturer's warranty shall apply for that particular piece of equipment or material.

PART 2 - PRODUCTS

2.01 MATERIALS AND WORKMANSHIP

A. Quality and Performance:

1. All materials and apparatus required for the work, except as particularly specified otherwise, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected and finished in every detail, and shall be so selected and arranged as to fit properly into the building spaces.

2. Where no specific kind or quality of material is given, a first-class standard article as approved by the Engineer shall be furnished.

3. Conform to applicable Specifications and standards.

4. Comply with size, capacity, make, type, dimensions, and quality specified, unless variations are specifically approved in writing by

Engineer.

5. Manufactured and Fabricated Products:

   a. Design, fabricate, and assemble in accord with the best engineering and shop practices.

   b. Manufacture like parts of duplicate units to standard sizes and gages, to be interchangeable.

   c. Two or more items of the same kind shall be by the same manufacturer.

   d. Products shall be suitable for service conditions.

6. All hardware, such as nuts, bolts, washers, lockwashers, threaded rod, and the like, shall be adequately sized to do the intended job, and to take some physical abuse.

7. Do not use material or equipment for any purpose other than that for which it is designed or is specified.

8. Except as specifically indicated or specified, materials and equipment removed from an existing structure shall not be used in the completed work.

2.02 SUBSTITUTIONS AND PRODUCT OPTIONS

A. Contractor's Options:

1. For products specified only by reference standard, select any product meeting that standard.

2. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named, which complies with the Specifications.

3. For products specified by naming one or more products or manufacturers and "or equal", Contractor shall submit a request for substitutions for any product or manufacturer not specifically named.

B. Substitutions:

1. Contractor shall obtain written approval from Engineer for the use of substitute products, materials or manufacturers claimed as equal to those specified. Requests for substitution approvals shall be made by bidding Contractors and Subcontractors, and not by material and equipment suppliers

2. Each item of equipment proposed shall be a standard catalog product of an established manufacturer and of equal quality, finish, performance, and durability to that specified. Each item shall comply with the requirement for Substitutions and Product Options described in this section.

3. Substitutions offered shall be supported by submittal of complete data.

4. Substitution submittal shall include manufacturer's data, test reports, performance data and certifications, dimensions, drawings, samples and other information as required to permit determination by the Engineer whether the offered substitute is equal to the specified standard.

5. Engineer shall be the judge of the acceptability of the proposed substitution.

6. The Engineer will review requests for substitutions and notify Contractor, in writing, of the decision to accept or reject the requested substitutions.

C. Contractor's Representation: A request for a substitution constitutes a representation that Contractor:

1. Has investigated the proposed product and determined that it is equal to or superior in all respect to that specified.

2. Has compared dimensions of the proposed product to the specified product, and has determined that the proposed product will fit properly in the available space, with adequate clearances for safety and maintenance.

3. Will provide the same warranties or bonds for the substitution as for the product specified.

4. Will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete and operational in all respects.

5. Waives all claims for additional costs caused by the substitution which may subsequently become apparent.

D. Any substitute item installed on the project, which has not been approved in writing by the Engineer, shall be removed and replaced by the Contractor with the required specified item, at no cost to the Owner.

2.03 EQUIPMENT DEVIATIONS

A. Where the Contractor proposes to use an item of equipment other than that specified, scheduled, or detailed on the Drawings, which requires any redesign of the structure, partitions, foundations, piping, wiring, ductwork, or any other part of the mechanical, electrical, plumbing, structural, architectural or civil work, all such redesign, and all new drawings and detailing required therefore, shall be prepared by or for the Contractor at his own expense and submitted for approval by the Engineer.

B. Where such approved deviation requires a different quantity and arrangement of ductwork, piping, wiring, conduit, equipment, structures and the like from that specified or indicated on the Drawings, the Contractor shall furnish and install all such piping, structural supports, insulation, controllers, motors,

starters, electrical wiring and conduit, and any additional material and equipment required by the system, at no additional cost to the Owner.

C. The Contractor shall guarantee that equipment other than that specified provides performance equal to specified equipment.

2.04 DIELECTRIC CONNECTIONS

A. A dielectric connection shall be used at any point within the ductwork or piping systems where dissimilar metals meet.

B. Provide bronze ball valves or isolation flanges for piping dielectric isolation. Dielectric unions are not acceptable.

C. Supports, brackets, and hangers touching piping or ductwork shall be same material as piping or ductwork, or a dielectric isolation material shall be installed between the piping or ductwork and its supporting members.

2.05 ACCESS DOORS

A. Access doors in building surfaces shall be furnished and installed by the General Contractor. The Mechanical Contractor shall coordinate sizes and required locations of all required access doors.

B. Access doors shall be provided for concealed equipment furnished under this division requiring periodic inspection, servicing or maintenance, where such equipment is located above nonremovable ceilings or behind walls.

C. 'B' Label Doors shall be used where installed in fire partitions. Doors shall have a fire rating not less than the adjacent material.

D. Access doors shall otherwise be as specified in the Architectural sections of the Specifications, and on the Drawings.

E. Access doors in ductwork and related surfaces shall be provided by the Mechanical Contractor as specified in Division 23 - Ductwork.

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall provide all materials and equipment called for in these Specifications and accompanying Drawings, complete in every respect. Anything called for in the Specifications and not shown on the Drawings or shown on the Drawings and not called for in the Specifications, shall be furnished by the Contractor.

B. These Specifications and Drawings are intended to require finished work, tested and ready for operation. Whenever the word "provide" is used, it shall mean "furnish and install complete and ready for use."

C. The Drawings are diagrammatic and are not intended to show each and every

duct, pipe, fitting, valve, damper, pipe hanger, and the like, or a complete detail of all the work to be done; but are for the purpose of illustrating the type of system, showing pipe sizes, duct sizes, equipment locations, and the like, and special conditions considered necessary for the experienced mechanic to take off his materials and lay out his work. This Contractor shall be responsible for taking such measurements as may be necessary at the work site and adapting his work to local conditions.

D. Conditions sometimes occur which require certain changes in the Drawings and Specifications. In the event that such changes in the Drawings and Specifications are necessary, the same are to be made by the Contractor without expense to the Owner, providing that such changes do not require furnishing more materials, or performing more labor than the true intent and meaning of the Drawings and Specifications. It shall be understood that while the Drawings are to be followed as closely as circumstances will permit, the Contractor is held responsible for the installation of the system according to the true intent and meaning of the Drawings. Anything not entirely clear in the Drawings and Specifications will be fully explained if request is made to the Engineer. Should conditions arise where, in the judgment of the Contractor, certain changes will be advisable, the Contractor shall communicate with the Engineer and secure his approval of these changes before going ahead with the work.

E. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

F. Work such as excavation, backfill, concrete, flashing, wiring, and the like, which is required by the work of this Division shall be performed in accordance with the requirements of all applicable section of the Specifications.

G. Some items of equipment may be specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on the Drawings, or as required for complete systems.

H. Provide all items required to complete the construction in accordance with reasonable interpretation of the intent of the Drawings and Specifications. Any minor items required by code, law or regulations shall be provided whether or not specified or specifically shown where it is a part of a major item of equipment, or of the control system specified or shown on the plans.

I. Conflicts between the requirements of this Specification, standards, purchase orders or design drawings shall be referred to the Engineer clarification before proceeding with work on the affected parts.

J. Contractor shall follow the Drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Engineer shall be consulted before proceeding with the installation.

3.02 MANUFACTURER'S INSTRUCTION

A. When Contract Documents require that installation of work shall comply with

manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in the installation, including two copies to Engineer. Maintain one set of complete instructions at the job site during installation and until completion.

B. Handle, install, connect, clean, condition and adjust products in strict accord with such instructions and in conformity with specified requirements. Do not omit any preparatory step or installation procedure unless specifically modified or exempted by Contract Documents, or by the Engineer in writing.

C. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with the Engineer for further instructions. Do not proceed with work without clear instructions.

3.03 DELIVERY, STORAGE, AND HANDLING

A. Transportation and Handling:

1. Ship items in appropriate labeled containers and crates.

2. Protect items from physical damage during shipment.

3. Receive, unload, uncrate and inspect all items specified and required for proper execution of this portion of work.

4. Upon receipt of items at project site, examine surfaces for defects and damage.

5. Return defective or damaged parts of supplier for repair or replacement so that schedule of this portion of work is not impaired.

6. Identify all documents certifying quality and compliance with Specifications and deliver to Engineer.

B. Storage and Protection:

1. Contractor shall provide satisfactory means of weather and security protection for materials, products, tools and equipment, such as trailers or other enclosures.

2. Store products in accord with manufacturer's instructions, with seals and labels intact and legible.

3. Store pipe and associated accessories off floor or off ground. Protect ends of pipe, valves, and fittings from weather and abuse; keep open ends sealed or covered until removed for installation.

4. Store equipment and specialties in safe, clean, dry areas with open ends and pipe connection points covered until removed for installation.

5. Store products subject to damage by the elements in weathertight enclosures. Maintain temperature and humidity within the ranges required by manufacturer's instructions.

6. Protection After Installation: Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.

C. Shrink Wrapping Ductwork - Ductwork shall be delivered to the site with ends shrink wrapped to avoid exposing inside of ducts to dirt, dust, and moisture.

3.04 SURVEYS AND MEASUREMENTS

A. The Contractor shall base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check correctness of these as related to the work.

B. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the Drawings and Specifications, he shall notify the Engineer and shall not proceed with his work until he has received instructions from the Engineer.

3.05 WORKMANSHIP

A. The Contractor shall furnish the services of an experienced superintendent, who shall be constantly in charge of the installation of the work, together with all skilled workmen, fitters, metal workers, welders, helpers, laborers and the like, required to unload, transfer, erect, connect, adjust, start, operate and test each system.

B. All work shall be done by first-class and experienced mechanics, properly supervised. It is understood that the Owner has the right to stop any work that is not being properly done and has the right to require that any workman, deemed incompetent by the Engineer, be removed from the job and a competent workman substituted therefore.

C. All equipment and material shall be installed in accordance with the recommendations of the manufacturer, unless otherwise specifically indicated on the Drawings or Specifications, or unless otherwise approved by the Engineer. This shall include the performance of such tests as the manufacturer recommends.

3.06 SCAFFOLDING, RIGGING, HOISTING AND CONTROLS

A. The Mechanical Contractor shall provide all construction aids, scaffolds, rigging, staging, ladders, ramps, railings, hoists, cranes, chutes, tools, services, facilities, equipment and the like as required for delivery, erection, and installation of the work.

B. The Mechanical Contractor shall provide and maintain all barriers as required to prevent public entry, and to protect the work, work by others, and areas accepted for substantial completion from construction operations.

C. Remove same from premises when no longer required.

3.07 SAFETY REQUIREMENTS

A. Contractor shall comply with the Owner's general safety rules, including insurance requirements. Contractor shall instruct all of his employees and subcontractors and shall take all practicable measures to enforce compliance with all of the applicable safety and security rules and regulations in and adjacent to these areas, to insure the least possible interruption of or interference with Owner's operations and work by others.

B. The finished installation of all systems and equipment shall be safe, creating no hazard when operating or at rest. All moving parts shall be covered with appropriate guards. All rough edges of equipment and materials shall be made smooth.

C. Applicable OSHA requirements shall be met in full.

3.08 ACCESS AND CLEARANCES

A. The Contractor shall verify the size of shafts and chases, and the adequate clearance in double partitions and hung ceilings for the proper installation of his work. He shall cooperate with the General Contractor and all other contractors whose work is in the same space, and shall advise the General Contractor of his requirements. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. Equipment shall include but not be limited to sensors, controls, fire dampers, valves, traps, cleanouts, vent and drain points. Access to equipment shall be in accordance with the manufacturer's recommendations and good trade practice.

C. The Contractor shall locate all equipment to avoid conflicts and clearance requirements required by other trades.

D. Locate equipment to maintain clearances required by electrical panels.

E. Equipment access and clearances shall comply with applicable code requirements.

F. Provide access doors in ductwork, equipment, and the like as required for good maintenance and service access.

G. Unless otherwise noted, access doors required in building surfaces shall be provided by the General Contractor. The Mechanical Contractor coordinate exact locations and size of access doors needed for his equipment, valves, controls, or other devices requiring service.

H. Minor deviations from Drawings may be made to allow for better accessibility. Such deviations shall be approved by the Engineer.

3.09 OPENINGS, SLEEVES & FLASHINGS

A. The General Contractor shall provide all duct and pipe openings, chases and shafts in all existing and new construction as specified. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient time for the General Contractor to make the necessary

provisions. The Mechanical Contractor shall be responsible for the correct size and location of each opening for his equipment even though these openings are provided by the General Contractor.

B. The Mechanical Contractor shall arrange for necessary openings in building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, Engineer 's approval shall be obtained before cutting, and portions cut shall be restored to their former condition by this Contractor.

C. The Mechanical Contractor shall provide pipe sleeves to the General Contractor for installation where pipes pass through walls, floors or partitions. Sleeves through partitions and walls shall be 16 gauge minimum steel pipe flush with both sides of walls or partitions, and coated with rust inhibitive paint. Seal piping penetrations thru outside walls and floor for weatherproofing and leak tight.

D. Sleeves for uninsulated pipes shall be large enough to permit expansion movement. Sleeves shall generally be 1" larger in dimension that the outside diameter of the pipe. Coordinate exact clearance requirements for fire stopping as required by data sheets for UL System numbers with General Contractor.

E. Sleeves for insulated pipes shall be large enough to accommodate insulation and to permit expansion movement. Insulation shall be continuous through sleeves. Sleeves shall generally be 1" larger than outside diameter of insulation. Coordinate exact clearance requirements for fire stopping as required by data sheets for UL System numbers with General Contractor.

F. Where smooth, uniform penetrations can be made in existing concrete wall construction by means of core drilling, sleeves shall not be required. However, penetrations made in this manner shall meet all the above requirements for sleeves, such as sizes, clearances, sealing requirements, UL fire stopping, and the like.

G. Where pipes penetrate firewalls, fire partitions, or fire rated floors, U.L. approved fire stop seals shall be provided. Pack all other spaces between sleeves and insulation or pipe with fiberglass to make airtight unless indicated otherwise by U.L. approved installation methods.

3.10 CUTTING AND PATCHING

A. General Contractor shall provide all cutting and patching necessary to install the work specified in this Division. Patching shall match adjacent surfaces, or new finishes as specified.

B. No structural member shall be cut without the specific approval of the Engineer except as specifically detailed on the Drawings. All such cutting and reinforcing shall be done in a manner directed by the Engineer.

C. Cutting and patching of footings after general construction will not be permitted.

D. The General Contractor shall provide all duct and pipe openings, chases and shafts in all existing and new construction. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient

time for the General Contractor to make the necessary provisions. This Contractor shall be responsible for the correct size and location of each opening for his equipment even though these openings are provided by the General Contractor.

E. The Mechanical Contractor shall arrange for necessary openings in building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, Engineer's approval shall be obtained before cutting, and portions cut shall be restored to their former condition by this Contractor.

F. Cutting and patching of roof openings in existing facilities shall be coordinated with the Owner. If required to maintain bonded warranty, this work shall be performed by the bonding agent. Verify specific requirements for maintaining warranty for the existing roof with the Owner.

3.11 FIRE STOP SEALS

A. The General Contractor shall provide all fire stopping for pipe and conduit thru penetrations thru existing and new fire rated floors, partitions, and walls. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient time for the General Contractor to make the necessary provisions and shall be responsible for the correct size and location of each opening.

B. Fire stop seals shall be installed in strict accordance with the UL Fire Resistance Directory and the manufacturer's recommendations and data sheets for each type of opening or void.

C. Fire stop seals shall be an intumescent material capable of expanding up to 10 times when exposed to temperatures beginning at 250^{o}F. All fire stop systems shall be UL Classified and have ICBO, BOCAI, and SBCCI (NER 243) approved ratings to 4 hours for floor penetrations and 2 hours for wall and partition penetrations per ASTM E-814 (UL 1479). Manufacturer shall be 3M, or equal by Dow Corning.

D. All surfaces that will be in contact with the penetration seal materials shall be cleaned of dirt, grease, oil, loose materials, rust, or other substances that may affect the proper fitting and adhesion of the installed sealant materials. Surfaces shall be smooth and without gouges or other irregularities.

E. Protect materials installed to seal fire rated penetrations from damage where installed on surfaces subject to traffic.

F. Verify thorough penetration seals by inspection of installed materials. Provide for accessibility to penetration seals for inspection by applicable code authorities.

3.12 VIBRATION ISOLATION

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer.

B. For moving machinery, sound or vibration noticeable outside of the room in which it is installed, or annoyingly noticeable inside its own room, will be

considered objectionable.

C. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at the Contractor's expense.

3.13 PROTECTION

A. Contractor shall protect all work and material from damage, and shall be liable for all damage during construction.

B. Contractor shall be responsible for work and equipment until all construction is finally inspected, tested, and accepted. He shall protect work against theft, injury or damage; and shall carefully store material and equipment received on site which are not immediately installed. He shall close open ends of work, including ductwork, pipe and equipment, with temporary covers or plugs during storage and construction to prevent entry of obstructing materials.

C. Contractor shall be responsible for the Owner’s existing facilities and equipment during construction and testing of new work and equipment provided under this project. Contractor shall protect existing facilities and equipment against theft, injury, or damage.

D. See the Contract Documents, including the General Conditions, Supplementary General Conditions and General Requirements.

E. During construction, cover open ends of air handling units and ducts with 6 mil polyethylene secured with duct tape.

3.14 HOUSEKEEPING AND CLEANING

A. Refer to General Conditions and Supplementary General Conditions.

B. Maintain the work site and surrounding areas reasonably clean and free of dirt, debris, waste and surplus materials.

C. Maintain clean and safe working conditions.

D. Daily: During construction, execute daily cleaning to keep the work, the site and adjacent properties free from accumulations of waste materials, rubbish and windblown debris, resulting from construction operations.

E. Waste Containers: Provide on-site containers for the collection of waste materials, debris and rubbish.

F. Waste Removal: Remove waste materials, debris and rubbish from the site periodically and dispose of at legal disposal areas away from the site.

G. Dust Control: Schedule operations so that dust and other contaminants resulting from work will not interfere with other operations.

H. Final Cleaning:

1. Employ skilled workmen for final cleaning.

2. Remove grease, mastic, adhesive, dust, dirt, stains, fingerprints, labels, and other foreign materials from sight-exposed interior and exterior surfaces.

3. Chrome plated fittings, fixtures, piping and trim shall be polished upon completion.

4. Prior to final completion, Contractor shall conduct an inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that the entire work is clean.

3.15 PAINTING

A. Touch up, or repaint completely, equipment on which factory paint has been damaged. Paint all miscellaneous support steel exposed to weather or visible within an occupied space or mechanical room. Painting materials and methods shall be as specified under the Specification Division and Section titled "Painting".

B. Provide one coat of standard shop primer on all uncoated steel supports, hangers, and components. In addition to primer coat, provide two coats of exterior paint for outdoor or locations exposed to humid conditions.

C. Provide one coat of standard shop primer and two coats of paint where scheduled or specified for piping to be painted.

D. Primer: Standard shop primer equal to Steel Structures Painting Council (SSPC) Specification No. 13. Total dry film thickness shall be not less than 2.5 mils. Verify compatibility of primer with specified finish paint. All miscellaneous steel supports provided for equipment, piping, and accessories furnished shall be fully coated with approved shop primer paint. Uncoated, bare steel supports will not be accepted.

E. Paint: Paint shall be weather resistant high-gloss exterior enamel for use over primed surfaces. Paint shall be Glidden 4500 Glid-Guard Industrial Enamel or equal by Moore or Duron.

3.16 ASBESTOS CONTAINING MATERIALS (ACM): Every effort has been made by the Owner to identify and remove any to ACM from the existing facility prior to the start of Contractor work. The Contractor is responsible for notifying the Owner upon discovery of any materials which the Contractor suspects may contain asbestos. The Owner wil arrange for testing and removal of any ACM. The Contractor shall schedule his or her work in such a manner that minor interruptions for ACM removal will not constitute work stoppages.

3.17 RECORD DOCUMENTS: Contractor shall maintain at the project site one complete set of red-marked Contract Drawings and Specifications, continuously updated as the work progresses, to show all changes to the work and indicate actual installation of equipment and systems. Where deviations from scheduled equipment are provided, these deviations shall be indicated on updated and marked schedules.

3.18 PLACING IN SERVICE

A. Before being placed into operation, each item of equipment shall be serviced in accordance with the requirements of these Specifications and the manufacturer's recommendations. This servicing shall include alignment, lubrication, instrument liquids, instrument and control calibrations and adjustments, testing and adjusting of operating controls.

B. Ducts, plenums and casings shall be cleaned of all debris and blown free of all particles of rubbish and dust before startup.

C. Piping shall be continuously flushed with clean water until flushing water leaving the piping runs clean. Flushing shall be done at sufficient velocity to ensure proper cleaning. Refer to piping Specifications for additional cleaning requirements.

D. Motors shall be "bumped" to assure proper rotation.

E. Alignment of all shafts, couplings, pulleys, belts and the like, shall be verified.

3.19 TESTING AND BALANCING: Provide complete testing and balancing of all systems and equipment, as specified in separate section of this Specification Division.

3.20 OPERATIONAL TESTS AND SERVICING

A. In addition to testing and balancing specified elsewhere in this division of the Specifications, the Contractor shall make all tests, trial operation balancing and balance tests, and the like, as specified and as directed by the Engineer to prove that all work under these Drawings and Specifications is in complete serviceable condition and will function as intended. All costs of tests shall be borne by Contractor.

B. Pulley sizes and belts shall be adjusted or changed as necessary to obtain the specified performance.

C. All controls, valves and equipment shall be adjusted to settings indicated.

D. At the completion of performance runs, the Contractor shall recheck all equipment and verify that each item is functioning correctly.

E. Upon completion of all work, each system shall be tested to determine if detection of objectionable noise or vibration is apparent during operation of the system. If any such objections are detected in the system or equipment, the Contractor shall be responsible for correcting the problem.

F. Bearings shall be re-lubricated as recommended by the equipment manufacturer.

3.21 ACCEPTANCE OF EQUIPMENT

A. The Contractor shall schedule field observation of all pressure tests, leak tests, equipment factory start-ups, and similar tests requiring field observation by the Engineer.

B. The Contractor shall schedule all inspections with the Engineer at least 48 hours prior to the time of inspection. Inspections shall be scheduled prior to

backfilling, and installation of ceilings, walls, or other work that would hinder access.

C. In the event that the Owner considers it impractical, because of unsuitable test conditions or some other factor, to execute simultaneous final acceptance of all equipment, portions of the installation may be certified by the Engineer for final acceptance when that portion of the system is complete and ready for operation.

D. The Contractor shall cooperate in making corrections to deficient work. If an unreasonable number of inspections are required by the Engineer as a result of the Contractor's failure to make corrections previously noted, the Contractor shall be responsible for the cost of such inspections. The cost of these inspections shall be based on the Engineer's hourly rate plus travel expenses.

3.22 FINAL CLEANING

A. Employ skilled workmen for final cleaning.

B. Remove grease, mastic, adhesive, dust, dirt, stains, fingerprints, labels, and other foreign materials from sight-exposed interior and exterior surfaces.

C. Chrome plated fittings, fixtures, piping and trim shall be polished upon completion.

D. Prior to final completion, Contractor shall conduct an inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that the entire work is clean.

3.23 TRAINING

A. Contractor shall schedule operation and maintenance training with the Owner. Provide written notice to the Owner of such training to confirm scheduling.

B. Instruct Owners' operators in proper operation and maintenance of all equipment and controls. Supervise the operation of the system until the Owners' operators are familiar with the equipment and controls. See other Specification Sections for additional requirements.

3.24 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Submit in within 30 days of shop drawing approval complete descriptive information, operating and maintenance instructions and spare parts lists for all equipment installed under this contract. All information shall be assembled in three ring binders with index tabs to identify each item of major equipment and each system.

B. Provide title sheet with job name, and the names, addresses and phone numbers of the Contractor, subcontractor, control subcontractor, related contractors, and material and equipment suppliers.

C. Each manual shall be self-contained and include information for efficient servicing of equipment supplied and installed under the contract.

D. Operating instructions shall explain maintenance procedures, methods of checking the systems for safe and normal operation, and the recommended procedure for safely stopping and starting the equipment and/or system.

E. Instruct Owner's personnel in proper operation and maintenance of all equipment and controls.

F. These requirements shall be fulfilled before any guarantee periods become effective so as to limit the possibility of claims arising from the absence of pertinent information.

3.25 CONTRACT CLOSEOUT SUBMITTALS

A. All record documents and close-out submittals shall be completed satisfactorily before final application for payment will be approved.

B. Evidence of compliance with requirements of governing authorities shall be submitted.

C. Provide one complete set of Contract Drawings and Specifications marked in red with all changes to the work to indicate actual installation.

D. Provide one complete set of Record Submittal Drawing prints marked in red with all changes to the work to indicate actual installation. These records are a specific contract requirement, and final payment will not be made until these Drawings and Specifications have been submitted in an acceptable form.

E. Operating & Maintenance Manuals: Submit as indicated in Division 1.

F. Testing & Balancing Reports: Submit as indicated in Division 1.

G. Guarantees, Warranties and Bonds: Submit as indicated in Division 1.

H. Spare parts and maintenance materials: Submit as indicated in Division 1.

I. Manufacturer’s startup reports: Submit as indicated in Division 1.

J. Inspection and Test Reports: Submit as indicated in Division 1.

K. Statement of payment of taxes: Submit as indicated in Division 1.

L. Affidavit of Payment of Debts and Claims: Submit as indicated in Division 1.

M. Affidavit of Release of Liens: Submit as indicated in Division 1.

END OF SECTION

SECTION 23 00 20
MECHANICAL DEMOLITION

PART 1 - GENERAL

1.01 WORK INCLUDED:

A. Work of this section includes demolition and removal of existing HVAC and piping materials and equipment shown on Demolition Drawings, and as necessary to complete the required construction. The required demolition includes, but is not limited to the following:

1. Protection of existing building equipment and fixtures as required to complete the work.

2. Removal of miscellaneous pipes, equipment, conduit, and controls associated with existing HVAC equipment. (Demo of electrical wiring shall be by Electrical Contractor.)

3. Removal and disposal offsite of all debris resulting from the demolition.

4. Protection of the Owner's existing building, pavement, remaining utilities, landscaping, and equipment throughout the work.

5. Protection of, and coordination with, Owner's on-going usage. Maintain egress/access at all times.

6. Protection of existing structural members.

7. Maintaining the building weathertight during demolition and construction.

8. Maintaining the building secure during demolition and construction.

B. Obtain any required permits and comply with all local ordinances for demolition work.

C. Provide all guardrails, barricades, and other safety measures.

D. Provide temporary partitions for noise and dust controls. Partitions are to remain in place throughout the construction period. Partitions are to be constructed using metal studs and drywall.

E. Clean-up of work areas on a daily basis.

F. Repair wall penetrations where ductwork, and/or piping is removed during demolition.

1.02 SUBMITTALS:

A. Submit a copy of all permits and certificates required for work of this section.

B. Submit demolition procedures and operational sequence for review and acceptance by the Owner. These procedures shall include the following:

1. Description of methods and procedures for protecting the existing building, equipment, fixtures, etc.

2. Description of methods and procedures for maintaining the building watertight during the construction.

1.03 PROTECTION:

A. Safety measures and methods shall be used to protect personnel and property to remain undisturbed.

B. Do not interfere with use of the building's operation except as approved by the Owner.

C. Provide and place bracing or shoring and be responsible for safety and support of remaining construction. Assume liability for such movement, settlement, damage, or injury.

D. Cease operations and notify the Owner immediately if safety of remaining construction appears to be endangered. Do not resume operations until safety is restored.

E. Use approved methods (including partitions with gypsum board covering) to provide dust control during demolition.

F. Provide protection to adjacent areas where work is in progress.

G. Provide temporary dewatering as required to accomplish specified construction.

H. Locate and deactivate all utilities prior to commencing demolition. Protect existing utilities to remain.

1.04 EXISTING SERVICES: If requested, the Owner may disconnect utility services. Any temporary disconnection of the utility services, prior to removal of the services in sections to be demolished, shall be planned and authorized by the Owner. Disruption to existing utilities, if approved, is to be held to absolute minimum time period. Interruption of existing utility services shall be scheduled with the Owner at least one week in advance.

1.05 JOB CONDITIONS:

A. Condition of Structures: The Owner or Engineer assume no responsibility for the actual condition of areas to be demolished.

1. Bidders for this work shall make such investigation as they deem necessary to arrive at the cost of this portion of the work. No extras will be paid for hidden conditions not indicated or expected.

2. Conditions existing at the time of inspection for bidding purposes will be maintained by the Owner in so far as practicable.

B. Inspection: The Contractor shall inspect the site to determine the extent of demolition work that will be required prior to submittal of bid. Demo drawings may not indicate all demolition required to complete the required construction.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Materials, equipment, and the like which are to be salvaged shall be removed in an approved manner. Deliver salvaged materials, equipment, and the like to the Owner's designated location.

B. Materials or parts of structures, not specifically specified on Drawings or designated by Owner to be salvaged, shall be properly disposed of at locations off the job site.

C. Repair existing openings to match adjacent materials and finishes where ductwork, piping, and equipment is removed.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Erect weatherproof and secure closures for exterior openings. Maintain exit requirements.

B. Erect and maintain dustproof partitions as required to prevent spread of dust, fumes and smoke to other parts of the building. On completion, remove partitions and repair damaged surfaces to match adjacent surfaces.

C. Carry out demolition work to cause as little inconvenience to adjacent occupied building areas as possible.

D. Construct protective enclosures around all equipment to remain.

3.02 DEMOLITION:

A. All demolition shall be performed in accordance with applicable codes and regulations of authorities having jurisdiction.

B. Demolish in an orderly and careful manner as required to accommodate new work and to suit construction phasing. Protect existing structural members and construction to remain.

C. Repair all demolition performed in excess of that required, at no cost to the Owner.

D. Burning of materials on site is not permitted.

3.03 REMOVAL:

A. If not indicated to be salvaged, remove demolished materials, debris, dust, tools and equipment from site upon completion of work. Leave site in a clean condition.

B. Transport all materials removed from demolished area and properly dispose of off-site. No items are to be abandoned in place.

3.04 REPAIR AND REPLACEMENT: Any damage to existing facilities, equipment, structure, or property resulting from demolition or construction by the contractor shall be repaired or replaced by the contractor to the satisfaction of the Owner.

3.05 SALVAGED EQUIPMENT AND MATERIALS:

A. Transport to the Owner's designated location any equipment or materials that are identified to be salvaged and submitted to the Owner.

B. Protect and store any equipment or materials identified to be reused or reinstalled.

END OF SECTION

GREENSBORO, NC Corporate
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SKA CONSULTING ENGINEERS

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York County EOC
HVAC Replacement

Specifications

SKA Job Number: 230200.0

November XX, 2023

CONSTRUCTION DOCUMENTS

Stephen Moorefield, PE

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Greensboro, North Carolina 27409
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TABLE OF CONTENTS

SECTION 010100
SUMMARY OF THE WORK

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

1.01 LOCATION OF SITE: 149 W. Black St., Rock Hill, SC 29730

1.02 SUMMARY OF THE WORK:

A. The work described in the Contract Documents, Base Bid, includes the furnishing of all labor, materials, equipment, and services necessary to complete the following:

1. Remove and dispose existing roof top air handling units, split-system units and associated air distribution.

2. Remove and dispose of existing computer room air conditioning units.

3. Installation of variable refrigerant flow systems and air distribution.

4. Installation of new computer room air conditioning units.

5. Installation of new Building Automation System.

6. Remove and dispose of existing ceiling grid and tiles.

7. Installation of new ceiling grid and tiles.

8. Remove and dispose of existing fluorescent lighting.

9. Installation of new LED lighting.

1.03 CONTRACTORS USE OF PREMISES:

A. General: The Contractor shall limit their use of the premises to construction activities in areas indicated; allow for Owner occupancy and use of areas that are not within the construction activities.

B. Use of Existing Building: Protect and maintain existing walkways, roofs, and equipment and parking lot facilities throughout the construction period. Repair damage caused by construction operations. Take all precautions necessary to protect the building and occupants during the construction period.

1.04 OWNER OCCUPANCY: The Owners/Employees will occupy the site and continue daily activities during the construction period. Cooperate with the Owner and project

liaison during construction operations to minimize conflicts and facilitate Owner usage. Perform the work so as not to interfere with the Owner use except as permitted for specific components of the work.

1.05 COORDINATION ISSUES: The Contractor shall coordinate with the schedule of work and work activities, the Owners and their representatives. These schedules shall be updated at periodic coordination meetings at the site.

1.06 STAGING AREA AND FIELD OFFICE:

A. Material Storage: Construction materials may be stored on the construction site (in accordance with manufacturer's recommendations), and shall not be placed to block or cause a hazard to pedestrian or vehicular traffic. Storage shall be in the staging area designated in the Preconstruction Conference unless otherwise approved by the Owner in writing.

B. The Contractor shall not wash debris including cementitious residue from tools and equipment into the storm sewer system, onto the grounds or onto the adjacent property.

1.07 TEMPORARY WATER AND ELECTRICITY: Water and electric utilities shall be accessible to the Contractor at the project site.

1.08 TEMPORARY TOILET FACILITIES: The Owner’s restrooms and other facilities shall not be used by any personnel involved in the work at this job. The Contractor shall provide for all construction personnel all sanitary conveniences and water as required by public authorities having jurisdiction over such matters and in accordance with the General Conditions.

1.09 PARKING: The Contractor shall use parking areas designated by the Owner for parking during the construction.

1.10 PROTECTION: Protection shall consist (in general) of the following:

A. Streets and Walks: Contractor shall protect all streets, parking areas and walks, and shall make all necessary repairs at his own expense.

B. Private Roads, Entrances, and Walks: Contractor shall protect private roads, entrances, and walks. He shall maintain them during course of work, and shall repair all damages to same at his own expense.

C. Buildings and Equipment: The Contractor shall protect all existing buildings and equipment and shall repair all damages to same at his own expense.

1.11 SAFETY:

A. The Contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the work. The Contractor shall comply with all safety and other applicable requirements in regard to all phases of this project including but not limited to all applicable regulations of OSHA and EPA. The Contractor shall handle all products with

appropriate precautions and care as stated on the Material Safety Data Sheets (MSDS) for each product.

B. The Contractor shall be responsible for preventing access to construction equipment, tools and materials that may be hazardous, misused or stolen.

1.12 CONTRACTOR'S SUPERVISION: The Contractor shall assign and maintain a single person as "job superintendent" on this project.

END OF SECTION

SECTION 010270
PAYMENT PROCEDURES

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 FORM OF SUBMITTAL: Prepare Application for Payment using AIA Document G-702, "Project Application and Project Certification for Payment" supported by AIA Document G-703, "Continuation Sheet". List approved Change Orders separately on each Application for Payment reflecting any increase or decrease in the cost of the work for the project, as the case may be.

1.02 Schedule of Values

2. GENERAL:

   A. Related requirements specified elsewhere:

      1. Scheduling and Sequencing
      2. Submittals
      3. Product Substitutions
      4. Construction Schedules

   B. Submit Schedule of Values to the Engineer, at least ten (10) days prior to submitting first Application for Payment.

   C. Upon request by Engineer, support values given with data that will substantiate their correctness.

   D. List quantities of materials specified under unit price allowances.

   E. Use Schedule of Values only as basis for Contractor's Applications for Payment.

3. FORM OF SUBMITTAL:

   A. Submit on AIA Document G-703 "Continuation Sheet", latest edition, or other approved Format acceptable to the Engineer.

   B. Use table of contents of this specification as basis for format for listing costs of work for sections under Divisions 2 - 16. Additional breakdown of the work in certain sections may also be provided.

   C. Identify each line item with number and title as listed in table of contents of this specification.

4. PREPARING SCHEDULE OF VALUES:

A. Itemize separate line item cost for each of following general cost items:

1. Performance and Payment Bonds.
2. Field Supervision and Layout.
3. Temporary Facilities and Controls.

B. Itemize separate line item cost for work required by each section of this specification including General Conditions of the Contract.

C. Break down installed costs into:

1. Cost of component products, delivered and unloaded at job site. (List under Column F, G-703).

2. Total installed cost, with overhead and profit. (List under Column C, G-703).

D. For each line item which has installed value of more than $10,000.00, break down costs to list major products or operations under each item.

E. Round off figures to nearest $1.00.

F. Make sum of total costs of all items listed in schedule equal to total Contract sum.

5. REVIEW AND RESUBMITTAL:

A. After review by Engineer, revise and re-submit Schedule (and Schedule of Material Values) as required.

B. Re-submit revised Schedule in same manner.

END OF SECTION

SECTION 013400
SUBMITTALS

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, Division 1 Specification Sections, apply to work of this Section.

1.01 SECTION INCLUDES:

A. Requirements for submittals.

B. Submittal procedures for shop drawings, product data, and samples.

1.02 RELATED REQUIREMENTS:

A. Definitions and additional responsibilities of parties (General Conditions).

B. Requirements of individual sections of Specifications.

1.03 SHOP DRAWINGS:

A. Present in a clear and thorough manner. Title each drawing with project name and number; identify each element of Drawings by reference to sheet number and detail.

B. Identify field dimensions; show relation to adjacent or critical features of work or products.

C. Drawing Size: Minimum 18" x 24; Maximum 24" x 36.

1.04 PRODUCT DATA:

A. Submit only pages which are pertinent; mark each copy of manufacturer's printed data to identify pertinent products, referenced to applicable specification section and item number.

B. Modify manufacturer's standard drawings and information in order to provide information specifically applicable to the work of this Contract. Delete information not applicable.

C. Provide manufacturer's preparation, assembly, and installation instructions as specified.

D. Provide manufacturer's technical and performance data and agency approvals.

1.05 SAMPLES:

A. Submit samples to illustrate functional characteristics of products, including parts and attachments.

B. Required samples are indicated in the individual specification sections.

C. Samples shall be of sufficient size and quantity to clearly illustrate range of color, texture, pattern, and functional characteristics of products.

D. Label each sample to clearly identify material, function, and applicable specification section and item number.

1.06 CONTRACTOR REVIEW:

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

B. Coordinate submittals with requirements of work and of Contract Documents. All submittals shall be transmitted in ample time to prevent delays in the work.

C. Sign or initial each sheet of shop drawings and product data, and label each sample to certify compliance with requirements of Contract Documents. Notify Project Manager in writing at time of submittal of any deviations from requirements of Contract Documents.

D. Do not fabricate products or begin work which requires submittal until return of submittal with Project Manager acceptance.

1.07 SUBMITTAL REQUIREMENTS:

A. Submit to Project Manager or his representative as designated by the Project Manager.

B. Transmit submittals in accordance with approved progress schedule and in such sequence to avoid delay in the work or work of other contracts or sections.

C. Provide 6" x 6" blank space on each submittal for Contractor and Project Manager stamps.

D. Apply Contractor's stamp, signed or initialed, certifying to review and verification of products, field measurements, field construction criteria, and conformance with requirements of work and Contract Documents.

E. Coordinate submittals into logical groupings to facilitate interrelation of several items.

F. Number of submittals required:

1. Shop Drawings: Submit one (1) in PDF format.

2. Product Data: Submit in PDF format.

3. Samples: Submit the number required in each section of Specifications, but in no case less than two (2). Submit applicable product data with samples.

G. Submittals shall contain:

1. The date of submission and the dates of any previous submissions.

2. The project title and number.

3. Contract identification:

    a. Contractor
    b. Supplier
    c. Manufacturer

4. Identification of the product with the applicable specification section and item number.

5. Field dimensions, clearly identified as such.

6. Relation to adjacent or critical features of the work or materials.

7. Applicable standards, such as ASTM or Federal Specification numbers.

8. Identification of deviations from Contract Documents.

9. Identification of revisions on resubmittals.

10. Contractor's stamp "For Approval Only" (all submittals).

11. Contractor's stamp certifying review of submittal (Product Data and Samples).

12. Contractor's stamp "approved by Contractor" (Shop Drawings).

1.08 RESUBMITTALS:

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

B. Shop Drawings, Product Data:

1. Revise initial drawings or data, and resubmit as specified for the initial submittal.

2. Clearly indicate any changes which have been made.

3. When stamped for construction, submit two (2) reproducibles of shop drawings to the Construction Manager.

C. Samples: Submit new samples, as specified for the initial submittal.

1.09 PROJECT MANAGER DUTIES:

A. Review submittals with reasonable promptness and in accordance with schedule.

B. Affix stamp and initials or signature, and indicate requirements for resubmittal, or approval of submittal.

C. Return submittals to Contractor for distribution or for resubmission.

D. Project Manager may designate submittal review to the Engineer or to a representative of the Project Manager.

1.10 CONSIDERATION OF SUBSTITUTIONS:

A. Substitutions for specified products will be considered only if the specified product is not obtainable; or if delivery date of specified product is such that scheduled date of substantial completion of the Work will be delayed if the specified product remains a requirement; or if, after an order has been placed, circumstances beyond the Contractor's control, such as labor disputes affecting manufacture or delivery of product cause such a delay; or for any other reason the Owner agrees the substitution may be in his best interest.

B. Qualifications: Substitutions will not be considered if:

1. They are indicated or implied on shop-drawing submittals without having been formally requested in accordance with provisions specified herein.

2. For their implementation, they require a major revision in the Work in order that their use may be accommodated.

3. They materially alter the design concept, including color or function originally intended by the specified product.

4. They do not meet all of the physical and performance requirements contained in the Project Specifications for the specified product.

5. They do not equal or exceed the product specifications for the specified product.

1.11 CONTRACTOR'S REPRESENTATION:

A. By submitting the Request for Substitution, the Contractor represents that he:

1. Has investigated the proposed substitute product, and

2. Has determined, by his best judgment and experience, that the proposed substitution is either necessary or in the Owner's best interest.

3. Will coordinate the installation of the accepted substitution, making such changes as may be required for the Work to be complete in all respects.

1.12 SUBMISSION PROCEDURES ON SUBSTITUTIONS:

A. State reason for making the request.

B. Identify product for which substitution is proposed by brand name and catalog number, giving Specifications Section and Article number where specified.

C. Identify, in similar manner, proposed substitution.

D. Itemize differences between product specified and proposed substitution, including, but not limited to, physical, color, function and guarantee considerations.

E. Itemize changes in adjacent work occasioned by proposed substitutions.

F. Accompany request with test data from independent laboratory substantiating quality and performance of proposed substitution.

G. Attach manufacturer's complete instructions on storage, handling and installation.

H. State proposed change to the Contract Sum and proposed change to the Contract Time if substitution is accepted and confirmed by Change Order. If the proposed substitution involves a change to the Contract Sum, any change in cost of adjacent or related work shall be included also.

I. State the number of days (not less than 15) during which the substitution as submitted is subjected to acceptance.

1.13 ACCEPTANCE OR REJECTION:

A. The Engineer will promptly review requests for substitutions complying with the above provisions.

B. If no exceptions are taken, the substitution will be confirmed by Bulletin and a subsequent Change Order.

C. If rejected, the Contractor will be promptly notified, and the Contractor shall proceed with the Work in accordance with the Contract Documents.

1.14 SUBSTITUTIONS:

A. Prior to commencing work, the Project Manager will consider requests from the Contractor for substitutions. Substitutions will then be considered only when a product becomes unavailable due to no fault of the Contractor, or is approved as Equal to the specified product by the Designer.

B. Document each request with complete data substantiating compliance of proposed substitution with Specifications.

C. A substitution request constitutes a representation that the Contractor:

1. Has investigated the proposed product and determined that it meets or exceeds, in all respects, specified product.

2. Shall provide the same warranty for substitution as for specified product.

3. Shall coordinate installation and make other changes which may be required for work to be complete in all respects.

4. Waives claims for additional costs which may consequently become apparent.

D. Substitutions will not be considered when they are indicated or implied on Shop Drawings or Product Data submittals without separate written request, or when acceptance will require substantial revision of Contract Documents.

E. The Engineer will determine acceptability of proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.

END OF SECTION

SECTION 015000
CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 UTILITIES:

A. Provide utility services required for construction operations.

1.02 VENTILATION:

A. Provide, as required, facilities to maintain specific storage conditions as described within this specification.

B. Provide adequate ventilation of enclosed areas to prevent the accumulation of fumes, vapors, and gases.

C. Existing facilities may not be used for storage during construction.

1.03 SANITARY FACILITIES:

A. Provide and maintain required facilities and enclosures.

B. Owner's existing facilities shall not be used.

1.04 CLEANING DURING CONSTRUCTION: Demolition debris from construction operations shall not be allowed to accumulate and shall be removed from the site and disposed of daily, unless prior arrangement is made with the Owner.

1.05 REMOVAL: Provide removal services and coordinate placement and servicing of trucks or containers with the Owner. Existing facilities and services shall not be used.

1.06 PROTECTION OF FACILITIES:

A. The Contractor shall be responsible for guarding against fires and shall provide suitable and adequate fire extinguishers conveniently located at the site. Competent operators shall be in attendance at all times equipment is subject to use.

B. The Contractor is responsible for providing all necessary chutes, tarps, or other measures required to protect the walls, sidewalks, streets, parking areas and other work from damage, soiling, staining, etc., that could result from construction activity of this Contract. Any damage caused by construction activity shall be repaired by the Contractor at his own expense.

C. The Contractor shall fine grade any lawn area which is disturbed and shall reseed after work is complete.

D. Telephone numbers shall be given to the Project Manager for contacting the Superintendent and Foreman during off hours and weekends.

END OF SECTION

SECTION 015600
CLEANING UP

PART 1 - GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, Division 1 Specification Sections, apply to work of this Section.

1.01 REMOVAL OF DEBRIS:

A. All debris and waste materials shall become the property of the Contractor and the Contractor shall be responsible for removal of the debris from the project site on a daily basis or as approved by the Owner.

B. Demolition debris shall be removed in covered trucks or other method that prevents debris, litter, dust, etc. from falling onto streets, sidewalks or soil. Streets, sidewalks and other public and private spaces shall be kept clean and free from demolition debris at all times.

C. The Contractor shall be responsible for the cleanup of streets, driveways, sidewalks and landscaping. Failure to clean promptly (within one day's notice) will result in the Owner having areas cleaned and deducting costs for same from the Contractor's contract.

D. No storage of debris or trash will be allowed on the site.

1.02 DUST AND DEBRIS:

A. The Contractor shall not allow debris and dust to accumulate for more than one day before removing such from adjacent public streets and driveways as a result of the work of this project. At no time shall any accumulation be allowed which will create a hazard to safety or which will create bad public relations.

B. The measures to be used to prevent littering the pavement shall include (but does not constitute the only measure to be used, if necessary) the following:

1. Pick up droppings as they occur.

1.03 CLEANING UP: Before final inspection and acceptance of the project, clean work under the contract.

END OF SECTION

SECTION 016000
MATERIALS AND EQUIPMENT

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 PRODUCTS:

A. Products include materials, equipment and systems.

B. Comply with Contract Documents and referenced standards as minimum requirements.

C. Do not use or remove from site any materials and equipment removed from the existing structure, except as specifically required or allowed by Contract Documents.

D. All construction procedures and materials used in the work for this project shall comply with the following:

1. Contract Documents

2. Applicable Manufacturer's Specifications

3. Accepted standards/practices

4. Applicable building codes, both national and local

1.02 WORKMANSHIP:

A. Work shall be performed by persons qualified to produce workmanship and quality specified.

B. The Contractor's designated Superintendent shall provide full-time on-site supervision.

1.03 MANUFACTURER'S INSTRUCTIONS:

A. Work shall be performed in accordance with the Material Manufacturer's specifications as modified by the Contract Documents.

B. Conflicts between the Contract Documents and the Material Manufacturer's specifications shall be brought to the attention of the Project Manager prior to beginning construction. Work in this area shall not proceed until conflicts are satisfactorily resolved by Project Manager.

C. Provide Material Safety Data Sheets (MSDS) for all materials brought on the site.

1.04 TRANSPORTATION AND HANDLING:

A. Transport products by methods to avoid product damage; deliver all materials with Manufacturer's labels intact and legible.

B. Provide equipment and personnel to handle products by methods to prevent damage.

1.05 STORAGE AND PROTECTION:

A. The following are considered minimum requirements. Additional storage and protection requirements are specified in individual sections of the specifications.

B. Store all materials so as to maintain clean, dry, weathertight conditions and to protect against loss, damage, and wetting. Wet materials and/or materials indicating moisture contents above equilibrium shall be marked, rejected for installation, and removed from the site.

C. Materials temporarily stored on the roof shall be located in approved areas and shall be distributed in such a manner as to stay within the load limits of the roof construction.

D. Materials subject to moisture intrusion and damage shall be stored on clean, dry, and raised platforms so as to prevent wetting or moisture absorption and yet provide sufficient ventilation to prevent condensation. These materials shall be covered so as to be completely weathertight. Factory-applied wrapping shall be unacceptable as the sole means of protection.

E. Any materials which when subject to moisture intrusion may have a detrimental effect on the installation or performance of other components of the installed systems shall be stored as indicated in Items 1.05, B. and D.

1.06 PRODUCT OPTIONS:

A. The Contractor shall submit list of materials proposed in accordance with Section 01340.

B. Contractor Product Selection:

1. Products specified only by referenced standards: Any product meeting that standard.

2. Products specified by naming several manufacturers: Products of any named manufacturer meeting Specifications.

3. Products specified by naming one or more manufacturers and "or as approved": Submit a request for substitution in accordance with Item 1.07 of this section.

4. Products specified by naming only one (1) product or Manufacturer: There is no option and no substitutions will be allowed.

1.07 SUBSTITUTIONS:

A. Prior to commencing work, the Project Manager will consider requests from the Contractor for substitutions. Substitutions will then be considered only when a product becomes unavailable due to no fault of the Contractor, or is approved as Equal to the specified product by the Designer.

B. Document each request with complete data substantiating compliance of proposed substitution with Specifications.

C. A substitution request constitutes a representation that the Contractor:

1. Has investigated the proposed product and determined that it meets or exceeds, in all respects, specified product.

2. Shall provide the same warranty for substitution as for specified product.

3. Shall coordinate installation and make other changes which may be required for work to be complete in all respects.

4. Waives claims for additional costs which may consequently become apparent.

D. Substitutions will not be considered when they are indicated or implied on Shop Drawings or Product Data submittals without separate written request, or when acceptance will require substantial revision of Contract Documents.

E. The Project Manager will determine acceptability of proposed substitution and will notify the Contractor of acceptance or rejection in writing within a reasonable time.

END OF SECTION

SECTION 017000
CONTRACT CLOSE-OUT

PART 1 – GENERAL

1.00 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.01 CLOSE-OUT PROCEDURES:

A. Conduct a final inspection at completion of piping and equipment installation, Owner, Inspection Representative, Project Manager.

B. The results of the inspection conducted by these parties shall be submitted in writing to the Project Manager.

C. Contractor shall remedy any and all deficiencies prior to final acceptance by the Project Manager.

1.02 FINAL CLEANING:

A. Execute cleaning prior to final inspection.

B. Remove waste and surplus materials, rubbish, and construction facilities from the site.

1.03 PROJECT RECORD DOCUMENTS: Submit "as built" documents with letter of transmittal indicating date, project number, Contractor's name and address, list of documents, and signature of Contractor.

1.04 GUARANTY/WARRANTY:

A. Provide guaranty/warranty properly executed in triplicate.

B. Guaranty/warranty shall state name of project, location, name of Owner, name of Contractor and Manufacturer, and date of final acceptance. Date of final acceptance will be as determined by the Project Manager for the entire system.

END OF SECTION

SECTION 017200
PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS: Drawings and general provisions of Contract, including Division 1 Specification Sections, apply to work of this Section.

1.02 MAINTENANCE OF DOCUMENTS:

A. Maintain at job site, one copy of:

1. Contract Drawings
2. Specifications
3. Addenda
4. Bulletins
5. Reviewed Shop Drawings indicating "No Exceptions Taken" or "Make Correction Noted"
6. Change Orders
7. Other Modifications to Contract
8. Field Test Records

B. Store documents in temporary field office, apart from documents used for construction. Do not use record documents for construction purposes.

C. Provide files and racks for storage of documents.

D. Maintain documents in clean, dry, legible condition.

E. Make documents available at all times for review by Engineer and Owner.

1.03 MARKING DEVICES: Provide colored pencils for marking.

1.04 RECORDING:

A. Label each document "PROJECT RECORD" in minimum 2 in. high printed letters.

B. Keep record documents current.

C. Do not permanently conceal any work until required information has been recorded.

D. Contract Drawings: Legibly mark to record actual construction:

1. Location of internal utilities and appurtenances concealed in construction referenced to visible and accessible features of structure.

2. Field change of dimension and detail.

3. Changes made by Change Order or Field Order.

4. Details not on original Contract Drawings.

E. Specifications and Addenda: Legibly mark up each section to record:

1. Manufacturer, trade name, catalog number, and Supplier of each product and item of equipment actually installed.

2. Changes made by Change Order or Field Order.

3. Other matters not originally specified.

F. Shop Drawings: Maintain as record documents; legibly annotate drawings to record changes made after review:

1.05 SUBMITTAL:

A. At completion of project, deliver record documents to Engineer.

B. Accompany submittal with transmittal letter, in duplicate, containing:

1. Date
2. Project title and number
3. Contractor's name and address
4. Title and number of each record document
5. Certification that each document as submitted is complete and accurate.
6. Signature of Contractor, or his authorized representative.

END OF SECTION

SECTION 09 51 23
ACOUSTICAL TILE CEILINGS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:

1. Acoustical tiles.
2. Metal suspension system.
3. Accessories.
4. Metal edge moldings and trim.

1.02 ACTION SUBMITTALS

A. Product Data:

1. Acoustical tiles.
2. Metal suspension system.
3. Accessories.
4. Metal edge moldings and trim.

B. Samples: For each exposed product and for each color and texture specified, 6 inches in size.

1.03 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.04 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size tiles equal to 2 percent of quantity installed.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver acoustical tiles, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

B. Before installing acoustical tiles, permit them to reach room temperature and a stabilized moisture content.

1.06 FIELD CONDITIONS

A. Environmental Limitations: Do not install acoustical tile ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical tile ceiling installation.

PART 2 - PRODUCTS

2.01 SOURCE LIMITATIONS

A. Source Limitations for Suspended Acoustical Tile Ceiling System: Obtain each type of acoustical ceiling tile and its suspension system from single source from single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Class A in accordance with ASTM E1264.
2. Smoke-Developed Index: 50 or less.

2.03 ACOUSTICAL TILES

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

1. Armstrong World Industries, Inc.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Acoustical Tile Standard: Provide manufacturer's standard tiles of configuration indicated that comply with ASTM E1264 classifications as designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.

C. Classification: Provide tiles as follows:

1. Type and Form, Type IV: Mineral base with membrane-faced overlay; Form 1, nodular Form 2, water felted.
2. Pattern: E (lightly textured).

D. Color: White.

E. Ceiling Attenuation Class (CAC): Not less than 35.

F. Edge/Joint Detail: Beveled, kerfed, and rabbeted.

G. Thickness: 3/4 inch.

H. Modular Size: As indicated on Drawings.

I. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.

2.04 METAL SUSPENSION SYSTEM

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

1. Armstrong Ceiling & Wall Solutions.
2. USG Corporation.
3. CertainTeed; SAINT-GOBAIN.

B. Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, fully concealed, metal suspension system and accessories of type, structural classification, and finish indicated that complies with applicable requirements in ASTM C635/C635M.

2.05 ACCESSORIES

A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.

B. Wire Hangers, Braces, and Ties: Provide wires as follows:

1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.106-inch- diameter wire.

2.06 METAL EDGE MOLDINGS AND TRIM

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

1. Armstrong World Industries, Inc.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations complying with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for of suspension-system runners.

1. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.
2. Finish: Painted white.

C. Extruded-Aluminum Edge Moldings and Trim: Where indicated, provide manufacturer's extruded-aluminum edge moldings and trim of profile indicated or referenced by manufacturer's designations, including splice plates, corner pieces, and attachment and other clips, complying with seismic design requirements.

1. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.
2. Baked-Enamel or Powder-Coat Finish: Minimum dry film thickness of 1.5 mils. Comply with ASTM C635/C635M and coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, including structural framing and substrates to which acoustical tile ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine acoustical tiles before installation. Reject acoustical tiles that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Measure each ceiling area and establish layout of acoustical tiles to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width tiles at

borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.

B. Layout openings for penetrations centered on the penetrating items.

3.03 INSTALLATION OF SUSPENDED ACOUSTICAL TILE CEILINGS

A. Install suspended acoustical tile ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.

B. Suspend ceiling hangers from building's structural members and as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.
2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
3. Secure wire hangers to ceiling suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
4. Space hangers not more than 48 inches o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches from ends of each member.
5. Do not use exposed fasteners, including pop rivets, on moldings and trim.

C. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.

D. Arrange directionally patterned acoustical tiles as follows:

1. As indicated on reflected ceiling plans.

E. Install acoustical tiles in coordination with suspension system and exposed moldings and trim. Place splines or suspension-system flanges into kerfed edges of tiles so tile-to-tile joints are interlocked.

1. Fit adjoining tiles to form flush, tight joints. Scribe and cut tiles for accurate fit at borders and around penetrations through ceiling.
2. Hold tile field in compression by inserting leaf-type, spring-steel spacers between tiles and moldings, spaced 12 inches o.c.

3.04 ADJUSTING

A. Clean exposed surfaces of acoustical tile ceilings, including trim and edge moldings. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.

B. Remove and replace tiles and other ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 23 00 10
MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS

A. The Contract Documents apply to this section.

B. The term "Contractor" and "Mechanical Contractor" referred to in Division 23 Specifications shall be interchangeable and shall be designated as the Mechanical Contractor assigned to work specified in Division 23.

1.2 REFERENCES

A.	Air Conditioning and Refrigeration Institute	ARI
B.	American National Standards Institute	ANSI
C.	Air Moving and Conditioning Association	AMCA
D.	American Petroleum Institute	API
E.	American Society for Testing and Materials	ASTM
F.	American Society of Heating, Refrigeration & Air Conditioning Engineers	ASHRAE
G.	American Society of Mechanical Engineers	ASME
H.	American Welding Society	AWS
I.	Anti-Friction Bearing Manufacturers Association	AFBMA
J.	Commercial Standards	CS
K.	Factory Mutual Corporation	FMC
L.	Institute of Boiler and Radiator Manufacturers	IBR
M.	Industrial Risk Insurers	IRI
N.	Manufacturers' Standardization Society of the Valve & Fittings Industry (Standard Practice)	MSS SP
O.	National Electrical Code (NFPA 70)	NEC
P.	National Electrical Manufacturer's Association	NEMA
Q.	National Fire Protection Association	NFPA
R.	Sheet Metal & Air Conditioning Contractors National Association	SMACNA
S.	Steel Structures Painting Council	SSPC
T.	Underwriters Laboratories	UL
U.	United States Standard	USS

1.3 CODES, REGULATIONS, TAXES, PERMITS & FEES

A. Work under this Division shall meet the applicable requirements of the following codes and standards:

1. Federal laws and regulations
2. South Carolina State Building Code, all volumes and parts
3. Local Authority Having Jurisdiction

B. Applicable code requirements shall govern where code requirements exceed the requirement of the Drawings and Specifications. The Drawings and

Specifications shall govern where the work and materials specified exceed applicable code requirements.

C. The Contractor shall give all necessary notices, obtain all permits and pay all sales taxes, fees and other costs, including utility connections or extensions, in connection with his work; file all necessary plans, prepare all documents and obtain and coordinate all necessary approvals of all authorities having jurisdiction; and deliver these to the Engineer before request for acceptance and final payment of the work.

D. The Contractor shall include in his work, without extra cost to the Owner, any labor, materials, service, apparatus, drawings, and the like, required in order to comply with all applicable laws, ordinances, rules and regulations, whether or not shown on Drawings and/or specified.

E. All materials furnished, and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, Underwriters' Laboratories, and with the requirements of all governmental departments having jurisdiction.

F. All materials and equipment for the electrical portion of systems shall bear the U.L. label, and shall be listed by the Underwriters' Laboratories, Inc.

G. All materials and equipment furnished under this Division shall be asbestos free.

1.4 EXAMINATION OF WORK SITE

A. Contractor and subcontractors shall, before submitting proposals, inform themselves of the conditions under which the work is to be performed, concerning the site of the work, the structure of the building, the obstacles which may be encountered, and all other relevant matters concerning the work to be performed.

B. No extra compensation will be allowed for failure to secure such information which was available prior to bidding. No extras will be allowed because of additional work necessitated by, or change in plans required because of, evident job conditions that are not indicated on the Drawings.

1.5 PROJECT SCHEDULE: Contractor and subcontractors shall, before submitting proposals, inform themselves of the Project Schedule, phase requirements, and complexities associated with the construction of the work under this contract. The Contractor shall assess all pertinent aspects of manpower requirements, coordination, supervision, scheduling, mobilization, equipment procurement, start-up, test and balance, demands of construction project management, and the like, to assure proper planning to meet the Project Schedule.

1.6 DRAWINGS AND SPECIFICATIONS

A. Contractor is cautioned to read the entire Contract Specifications and the entire set of Contract Drawings to assure that no reference to work by the Contractor is overlooked and to assure an understanding of the division of work between the various trades and/or contracts. Failure of the Contractor to do this shall not relieve him of any responsibility or remove any work from the contract.

B. The general arrangement of ductwork, piping and equipment shall be as shown on the Drawings. Detailed drawings of proposed departures due to actual field conditions or other causes shall be submitted to the Engineer for approval prior to installation. Any such changes shall be made without additional cost to the Owner. The Contractor shall examine carefully all Contract Documents, and shall be responsible for the proper fitting of materials and equipment in each location as indicated, without substantial alteration.

C. The Drawings are generally diagrammatic and may not indicate all off-sets, fittings, and accessories which may be required. The Contractor shall investigate all potential obstructions carefully, plan ahead, and provide at no additional cost to the Owner such fittings, valves, transitions and accessories as may be required to meet such conditions.

D. The right to make any responsible change in location of apparatus, equipment, and/or routing of piping or ductwork, up to the time of roughing in, without involving any additional expense to the Owner, is reserved by the Engineer.

E. Design is based on equipment indicated on Drawings, Schedules, and Specifications. Where the Contractor provides equipment different from equipment indicated in these documents, Contractor shall be responsible for and bear all cost for all changes to documentation, systems, and equipment required by furnishing this equipment

1.7 SUBMITTALS

A. Contractor shall submit within thirty (30) calendar days after award of contract, seven (7) copies of a complete list of products supplied by each manufacturer to be used on the job. No substitutions will be allowed after this date except in extenuating circumstances with approval of the Engineer. Use of a manufacturer's name or equipment number in these Specifications or on the Drawings shall not be considered as equipment approval by the Engineer without confirming shop drawing submittal and approval.

1.8 COORDINATION DRAWINGS

A. Coordination drawings specified in this section shall be prepared for mechanical equipment spaces, for equipment layout, fabrication, and installation of piping, ductwork, and the like. These drawings shall be prepared to coordinate clearances with other trades.

B. Coordination overlay drawings are required for each trade for all locations and shall be submitted as "shop drawings" for approval.

C. The Mechanical Contractor shall prepare complete computer generated coordination overlay drawings at a suitable scale not less that 1/4" = 1'-0" (Mechanical room coordination overlay drawings shall be ½" = 1'-0" scale). Each trade shall be responsible for providing an overly file of his work to the Mechanical Contractor. Drawings shall show each trades' work relative to the structural and architectural features of this facility and relative to other trades. Trade work shall include mechanical, plumbing, fire protection, electrical, telecommunications, and controls. The Engineer will provide AUTOCADD files of mechanical plans for the contractor's use. The coordination drawings when

completed shall have each contractor's approval stamp and signature indicating complete coordination between all trades. These drawings shall be submitted in the latest AUTOCADD format with each trade on a separate layer. No work shall begin nor shall any payment be provided until such time as the coordination shop drawings have been reviewed and approved by the Engineer.

D. If the Contractor installs work before coordination with other trades, he shall made the necessary changes in this work to correct interferences without extra charge to the Owner.

E. One complete set of approved coordination drawings shall be kept at the work site at all times, and shall be updated and maintained in the same manner as that required for Record Drawings. When specified herein, original tracings and/or CAD (computer-aided-drafting) drawings shall also be updated and maintained for submittal as part of Project Closeout.

1.10 SHOP DRAWINGS

A. Contractor shall submit for approval detail shop drawings of all equipment and materials listed in this section and in other Specification Sections. No materials or equipment required to be approved shall be delivered to the job site or installed until the Contractor has in his possession the approved shop drawings for the particular material or equipment. The submittals of shop drawings shall be completed as described herein. Submit the number of copies as indicated in Division 1.

B. Approval by the Engineer of shop drawings shall not be considered as a guarantee of quantities, measurements, or building conditions. Where drawings are provided, approval does not mean that drawings have been checked in detail. Approval does not in any way relieve the Contractor from his responsibilities or the necessity of furnishing material and performing work as required by the Contract Drawings and Specifications.

C. Shop drawings shall be submitted at least two weeks in advance to allow the Engineer ample time for review and approval. Submit for approval detailed, dimensioned drawings or catalog cuts, showing materials, finishes, construction, size, arrangement, operating clearances, performance characteristics, capacity, and the like. Each equipment submittal shall include manufacturer's installation instructions. Submittals which lack installation instructions shall be returned.

D. Written Description of Compliance Required:

1. Contractor shall prepare and submit a typewritten DESCRIPTION OF COMPLIANCE for each item in each shop drawing submittal. The DESCRIPTION OF COMPLIANCE shall follow the same format as the Contract Specifications. Every paragraph number used in the Specifications shall be used in the DESCRIPTION OF COMPLIANCE. A statement shall be written addressing each paragraph and requirement of the Specification.

2. The DESCRIPTION OF COMPLIANCE shall also address each line item of the Equipment Schedules on the Drawings, and the requirements of each note and detail on the Drawings.

3. Even if the Contractor believes the item being submitted complies exactly with the Specifications, the DESCRIPTION OF COMPLIANCE shall be prepared and included with the submittal. It often happens that the specified manufacturer and model number of an item are submitted, but available options and special requirements are not addressed, and the shop drawing must be returned for resubmittal. The requirement for a DESCRIPTION OF COMPLIANCE is intended to avoid this situation.

4. The Contractor shall itemize compliance for each Specification paragraph and requirements, for each line item of the schedule on the Drawings, and for each detail and note requirement on the Drawings, as follows:

   a. If the item being submitted for approval complies in <u>every detail,</u> write "Complies with Spec."

   b. If the item generally complies, but has certain exceptions, which the Contractor believes are minor or inconsequential, write "Complies with Exceptions." Write a description of each exception and describe why the Contractor believes the submittal should be approved.

   c. If the item does not comply, write "Does not comply." Then write a description of why the Contractor believes the item should be considered for approval, although it does not comply with the Specification. Regarding substitutions, refer to Substitutions and Product Options in Part 2 of this section.

   d. If the specific requirement does not apply to the item being submitted, write "Not Applicable." Then write a description of why the Contractor believes the requirement does not apply.

E. It is considered normal that some shop drawings may be required to be resubmitted to clarify or resolves some issues that are not clear or complete in the first submittal. However, when further resubmittal is necessary, after the first two (2) times of submittal for any shop drawing, to demonstrate complete compliance with the Contract Documents, it shall be considered indicative of inadequate review and preparation by the Contractor and his suppliers.

F. The time required for review and processing by the Engineer, after the first two (2) times of submittal of any shop drawing, shall be reimbursable to the Engineer, based on the Engineer's standard hourly billing rate schedule. Reimbursement shall be by the Owner to the Engineer, upon presentation of an invoice for this Additional Service. The Owner shall fund this reimbursement by a deduction from the Contractor's Contract Sum for this project.

G No payment for any material, equipment or labor will be approved until all required shop drawings for that material, equipment and labor have been approved by the Engineer.

H. Failure of the Contractor to submit shop drawings in ample time for review and approval shall not entitle him to an extension of contract time, and no claim for extension by reason of default will be allowed.

I. The Contractor shall be financially responsible for any price increase of shop drawing items from the time shop drawings are issued until they are returned to the Contractor for purchase of items.

J. Shop drawing samples, drawings, specifications, or catalogs submitted for approval shall be properly labeled indicating specific service for which material or equipment is to be used, section and article number of specifications governing, Contractor's name and name of job.

K. Identify each item submitted using applicable Tag Number, Specification section number or Drawing reference.

L. Catalogs, pamphlets, or other documents submitted to describe items for approval shall be specific. Items submitted shall be clearly marked. Data of a general nature will not be accepted. Data shall include copies of computation sheets indicating how unit capacity was determined where ratings are at other than standard conditions. Submit the same number of copies as required for shop drawings.

M. Shop Drawing Submittals Required:

1. Ductwork construction standards (Contractor's shop standards of fabrication)
2. Insulation - pipe, duct & equipment
3. Turning vanes
4. Grilles, registers, diffusers
5. Duct access doors, panels & test holes
6. Vibration isolation components
7. Pipe supports, hangers, and accessories
8. Mechanical identification for pipe, valves, ducts & equipment
9. Motors (furnish data along with the driven equipment)
10. Proposed Test and Balance Procedures
11. Piping materials, fittings, valves, and the like
12. Balancing dampers (rectangular and round)
13. Duct lining
14. Pressure gauges
15. Temperature gauges
16. Air handling units
17 Rooftop accessories (roof curbs, supports and the like)
18. Test readings (testing & balancing reports)
19. Controls system drawings, product cut sheets, sequence of operation (complete) for all systems (dampers, valves, devices, materials, etc.)
20. Other specific submittals as required by Specifications

1.11 COOPERATION

A. The Contractor shall give full cooperation to the Owner and other trades, and shall furnish any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

B. Where the work of the Contractor will be installed in close proximity to, or may interfere with work of the Owner or other trades, he shall assist in working out space conditions to make a satisfactory adjustment.

C. The successful Contractor shall employ, insofar as possible, such methods and means in the carrying out of this work as will not cause any interruption or interference with any separate Contractor or with Owner.

D. The Contractor shall furnish to other trades, as necessary for coordination, all templates, patterns, setting plans, shop details, and the like for the proper installation of work and for the purpose of coordinating adjacent work.

E. Piping, ductwork, and equipment to be concealed in walls, floors, and ceilings shall be installed before walls, floors, and ceilings are constructed.

F. Penetrations or openings required in walls, floors, ceilings, and roofs for piping, ductwork, equipment, or for any other reason, shall be sized, located and coordinated with other trades involved before construction of the walls, floors, ceilings and roofs.

1.12 COORDINATION - GENERAL

A. Temporary interruption of essential services or production may be allowed by the Owner during normal working hours. This possibility shall be scheduled in consultation with the Owner and shall not be of longer duration than essential to accomplish the purpose for such interruptions.

B. The Contractor shall obtain permits from the Owner for all welding or burning operations within the building(s) or above the roof of the building(s). The Contractor shall give such notice as will permit coordination of welding and burning operations with the Owner's activities and safety requirements. Approved mechanical igniters shall be used for burning and welding equipment.

C. Contractor shall perform only the specific work assignments set forth in the contract. In all other respects the Contractor and his employees, and his subcontractors shall observe the rights of the Owner to control and assign work not specifically described in this contract without interference or interruption from the Contractor, or his employees, or his subcontractors.

D. Contractor shall effect cooperation between his employees and those of Owner and Contractors on work awarded separately by the Owner, to the end that all work is properly anchored, installed and finished without hindrance or delay. Care shall be taken to avoid marring surfaces of the work of other Contractors, and each Contractor shall be held responsible for any damage to the work of others. Repair of new work shall be made by the original Contractor at the expense of the Contractor responsible for the damage.

E. Contractor shall obtain all necessary measurements of existing conditions and work by others in order that his work shall fit properly. No extra compensation will be allowed because of differences between actual dimensions and the measurements indicated on the Drawings.

1.13 COORDINATION OF INSTALLATION OF INSTRUMENTATION AND CONTROLS

A. The Mechanical Contractor shall coordinate with the Controls Subcontractor and the instrumentation and controls supplier regarding proper location and installation of sensing and control devices in piping, ductwork, and equipment.

The Controls Subcontractor shall be responsible for the sizing and selection of all sensors. The Controls Subcontractor shall also be responsible for providing instructions for the proper installation of his equipment, such as maintaining proper upstream and downstream straight-run dimensions on piping and ductwork to receive sensors.

B. The Mechanical Contractor shall be responsible for the final installation with regard to proper locations, workmanship and final insulation of equipment and systems in which the elements and controls are installed.

C. The Controls Subcontractor shall provide all electrical work required for the controls systems, as described in Section 23 09 00 and on the Drawings, all per the Electrical Specifications or specific installation requirements.

1.14 COORDINATION OF INSTALLATION OF FIRE SAFETY EQUIPMENT

A. The Mechanical Contractor shall coordinate with the Electrical Contractor, Fire Alarm Equipment Supplier, Instrumentation and Controls Supplier, and other as necessary regarding proper location and installation of sensing and control devices in ductwork and equipment.

B. Unless specified otherwise herein, the Electrical Contractor shall be responsible for the sizing and selection of all sensors, primary signaling devices and controls, such as, but not limited to, temperature sensors and ionization or smoke detectors. The Electrical Contractor, and his supplier, shall also be responsible for providing instructions for the proper installation of his equipment, such as maintaining proper upstream and downstream straight-run dimensions on ductwork to receive sensors.

C. The Mechanical Contractor shall install the primary sensing elements and controls provided by the Electrical Contractor. Installation of each item shall be as recommended by the Electrical Contractor. If his recommendation conflicts with or is substantially different from the Specifications and Drawings, the conflict or difference shall be resolved with the Engineer before proceeding.

D. The Mechanical Contractor shall be responsible for the final installation with regard to proper locations as required by the Electrical Contractor, workmanship and final insulation of equipment and systems in which the elements and controls are installed.

E. The Electrical Contractor shall be responsible for the installation and operation of the Fire Safety Systems complete, except as described above.

F. The Contractor is referred to the Instrumentation and Control Drawings and Specifications, and to Division 26, Electrical, for information.

1.15 INSPECTIONS

A. The Contractor shall be responsible for notifying and coordinating inspections with the authority having jurisdiction when work is ready for inspection. No work shall be covered or concealed until after inspection has been completed on such items as piping, ductwork, insulation, and the like.

B. The project will be observed by Engineer periodically as construction

progresses. The Contractor shall be responsible for notifying the Engineer at least 48 hours in advance when any work to be covered is ready for inspection. No work shall be covered or concealed until after observation and verification of testing has been completed on such items as piping, ductwork, insulation, and the like.

1.16 SYSTEM COMMISSIONING

A. Mechanical Contractor shall cooperate fully with the Engineer.

B. Provide assistance during commissioning as required to complete the commissioning procedures.

1.17 GUARANTEE

A. The Contractor shall guarantee the complete systems against defect due to faulty materials, faulty workmanship or failure due to negligence of the Contractor. This guarantee will exclude normal wear, maintenance, lubrication, replacement of expendable components, or abuse. During the guarantee period, the Contractor shall make good such defective workmanship and materials and any damage resulting from such defects within a reasonable time of notice given by the Owner.

B. The period of Guarantee for all materials, labor and equipment shall be 12 months from the date of final acceptance of the work unless noted otherwise. The period of guarantee on the affected equipment and systems shall be extended as necessary to provide one full season of operation of the cooling systems and of the heating systems.

C. Where items of equipment or material carry a manufacturer's warranty for a period in excess of twelve (12) months, the manufacturer's warranty shall apply for that particular piece of equipment or material.

PART 2 - PRODUCTS

2.01 MATERIALS AND WORKMANSHIP

A. Quality and Performance:

1. All materials and apparatus required for the work, except as particularly specified otherwise, shall be new, of first-class quality, and shall be furnished, delivered, erected, connected and finished in every detail, and shall be so selected and arranged as to fit properly into the building spaces.

2. Where no specific kind or quality of material is given, a first-class standard article as approved by the Engineer shall be furnished.

3. Conform to applicable Specifications and standards.

4. Comply with size, capacity, make, type, dimensions, and quality specified, unless variations are specifically approved in writing by

Engineer.

5. Manufactured and Fabricated Products:

   a. Design, fabricate, and assemble in accord with the best engineering and shop practices.

   b. Manufacture like parts of duplicate units to standard sizes and gages, to be interchangeable.

   c. Two or more items of the same kind shall be by the same manufacturer.

   d. Products shall be suitable for service conditions.

6. All hardware, such as nuts, bolts, washers, lockwashers, threaded rod, and the like, shall be adequately sized to do the intended job, and to take some physical abuse.

7. Do not use material or equipment for any purpose other than that for which it is designed or is specified.

8. Except as specifically indicated or specified, materials and equipment removed from an existing structure shall not be used in the completed work.

2.02 SUBSTITUTIONS AND PRODUCT OPTIONS

A. Contractor's Options:

1. For products specified only by reference standard, select any product meeting that standard.

2. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named, which complies with the Specifications.

3. For products specified by naming one or more products or manufacturers and "or equal", Contractor shall submit a request for substitutions for any product or manufacturer not specifically named.

B. Substitutions:

1. Contractor shall obtain written approval from Engineer for the use of substitute products, materials or manufacturers claimed as equal to those specified. Requests for substitution approvals shall be made by bidding Contractors and Subcontractors, and not by material and equipment suppliers

2. Each item of equipment proposed shall be a standard catalog product of an established manufacturer and of equal quality, finish, performance, and durability to that specified. Each item shall comply with the requirement for Substitutions and Product Options described in this section.

3. Substitutions offered shall be supported by submittal of complete data.

4. Substitution submittal shall include manufacturer's data, test reports, performance data and certifications, dimensions, drawings, samples and other information as required to permit determination by the Engineer whether the offered substitute is equal to the specified standard.

5. Engineer shall be the judge of the acceptability of the proposed substitution.

6. The Engineer will review requests for substitutions and notify Contractor, in writing, of the decision to accept or reject the requested substitutions.

C. Contractor's Representation: A request for a substitution constitutes a representation that Contractor:

1. Has investigated the proposed product and determined that it is equal to or superior in all respect to that specified.

2. Has compared dimensions of the proposed product to the specified product, and has determined that the proposed product will fit properly in the available space, with adequate clearances for safety and maintenance.

3. Will provide the same warranties or bonds for the substitution as for the product specified.

4. Will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete and operational in all respects.

5. Waives all claims for additional costs caused by the substitution which may subsequently become apparent.

D. Any substitute item installed on the project, which has not been approved in writing by the Engineer, shall be removed and replaced by the Contractor with the required specified item, at no cost to the Owner.

2.03 EQUIPMENT DEVIATIONS

A. Where the Contractor proposes to use an item of equipment other than that specified, scheduled, or detailed on the Drawings, which requires any redesign of the structure, partitions, foundations, piping, wiring, ductwork, or any other part of the mechanical, electrical, plumbing, structural, architectural or civil work, all such redesign, and all new drawings and detailing required therefore, shall be prepared by or for the Contractor at his own expense and submitted for approval by the Engineer.

B. Where such approved deviation requires a different quantity and arrangement of ductwork, piping, wiring, conduit, equipment, structures and the like from that specified or indicated on the Drawings, the Contractor shall furnish and install all such piping, structural supports, insulation, controllers, motors,

starters, electrical wiring and conduit, and any additional material and equipment required by the system, at no additional cost to the Owner.

C. The Contractor shall guarantee that equipment other than that specified provides performance equal to specified equipment.

2.04 DIELECTRIC CONNECTIONS

A. A dielectric connection shall be used at any point within the ductwork or piping systems where dissimilar metals meet.

B. Provide bronze ball valves or isolation flanges for piping dielectric isolation. Dielectric unions are not acceptable.

C. Supports, brackets, and hangers touching piping or ductwork shall be same material as piping or ductwork, or a dielectric isolation material shall be installed between the piping or ductwork and its supporting members.

2.05 ACCESS DOORS

A. Access doors in building surfaces shall be furnished and installed by the General Contractor. The Mechanical Contractor shall coordinate sizes and required locations of all required access doors.

B. Access doors shall be provided for concealed equipment furnished under this division requiring periodic inspection, servicing or maintenance, where such equipment is located above nonremovable ceilings or behind walls.

C. 'B' Label Doors shall be used where installed in fire partitions. Doors shall have a fire rating not less than the adjacent material.

D. Access doors shall otherwise be as specified in the Architectural sections of the Specifications, and on the Drawings.

E. Access doors in ductwork and related surfaces shall be provided by the Mechanical Contractor as specified in Division 23 - Ductwork.

PART 3 - EXECUTION

3.01 GENERAL

A. Contractor shall provide all materials and equipment called for in these Specifications and accompanying Drawings, complete in every respect. Anything called for in the Specifications and not shown on the Drawings or shown on the Drawings and not called for in the Specifications, shall be furnished by the Contractor.

B. These Specifications and Drawings are intended to require finished work, tested and ready for operation. Whenever the word "provide" is used, it shall mean "furnish and install complete and ready for use."

C. The Drawings are diagrammatic and are not intended to show each and every

duct, pipe, fitting, valve, damper, pipe hanger, and the like, or a complete detail of all the work to be done; but are for the purpose of illustrating the type of system, showing pipe sizes, duct sizes, equipment locations, and the like, and special conditions considered necessary for the experienced mechanic to take off his materials and lay out his work. This Contractor shall be responsible for taking such measurements as may be necessary at the work site and adapting his work to local conditions.

D. Conditions sometimes occur which require certain changes in the Drawings and Specifications. In the event that such changes in the Drawings and Specifications are necessary, the same are to be made by the Contractor without expense to the Owner, providing that such changes do not require furnishing more materials, or performing more labor than the true intent and meaning of the Drawings and Specifications. It shall be understood that while the Drawings are to be followed as closely as circumstances will permit, the Contractor is held responsible for the installation of the system according to the true intent and meaning of the Drawings. Anything not entirely clear in the Drawings and Specifications will be fully explained if request is made to the Engineer. Should conditions arise where, in the judgment of the Contractor, certain changes will be advisable, the Contractor shall communicate with the Engineer and secure his approval of these changes before going ahead with the work.

E. Minor details not usually shown or specified, but necessary for the proper installation and operation, shall be included in the work, the same as if herein specified or shown.

F. Work such as excavation, backfill, concrete, flashing, wiring, and the like, which is required by the work of this Division shall be performed in accordance with the requirements of all applicable section of the Specifications.

G. Some items of equipment may be specified in the singular; however, the Contractor shall provide and install the number of items of equipment as indicated on the Drawings, or as required for complete systems.

H. Provide all items required to complete the construction in accordance with reasonable interpretation of the intent of the Drawings and Specifications. Any minor items required by code, law or regulations shall be provided whether or not specified or specifically shown where it is a part of a major item of equipment, or of the control system specified or shown on the plans.

I. Conflicts between the requirements of this Specification, standards, purchase orders or design drawings shall be referred to the Engineer clarification before proceeding with work on the affected parts.

J. Contractor shall follow the Drawings in laying out work and check drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Engineer shall be consulted before proceeding with the installation.

3.02 MANUFACTURER'S INSTRUCTION

A. When Contract Documents require that installation of work shall comply with

manufacturer's printed instructions, obtain and distribute copies of such instructions to parties involved in the installation, including two copies to Engineer. Maintain one set of complete instructions at the job site during installation and until completion.

B. Handle, install, connect, clean, condition and adjust products in strict accord with such instructions and in conformity with specified requirements. Do not omit any preparatory step or installation procedure unless specifically modified or exempted by Contract Documents, or by the Engineer in writing.

C. Should job conditions or specified requirements conflict with manufacturer's instructions, consult with the Engineer for further instructions. Do not proceed with work without clear instructions.

3.03 DELIVERY, STORAGE, AND HANDLING

A. Transportation and Handling:

1. Ship items in appropriate labeled containers and crates.

2. Protect items from physical damage during shipment.

3. Receive, unload, uncrate and inspect all items specified and required for proper execution of this portion of work.

4. Upon receipt of items at project site, examine surfaces for defects and damage.

5. Return defective or damaged parts of supplier for repair or replacement so that schedule of this portion of work is not impaired.

6. Identify all documents certifying quality and compliance with Specifications and deliver to Engineer.

B. Storage and Protection:

1. Contractor shall provide satisfactory means of weather and security protection for materials, products, tools and equipment, such as trailers or other enclosures.

2. Store products in accord with manufacturer's instructions, with seals and labels intact and legible.

3. Store pipe and associated accessories off floor or off ground. Protect ends of pipe, valves, and fittings from weather and abuse; keep open ends sealed or covered until removed for installation.

4. Store equipment and specialties in safe, clean, dry areas with open ends and pipe connection points covered until removed for installation.

5. Store products subject to damage by the elements in weathertight enclosures. Maintain temperature and humidity within the ranges required by manufacturer's instructions.

6. Protection After Installation: Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.

C. Shrink Wrapping Ductwork - Ductwork shall be delivered to the site with ends shrink wrapped to avoid exposing inside of ducts to dirt, dust, and moisture.

3.04 SURVEYS AND MEASUREMENTS

A. The Contractor shall base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check correctness of these as related to the work.

B. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the Drawings and Specifications, he shall notify the Engineer and shall not proceed with his work until he has received instructions from the Engineer.

3.05 WORKMANSHIP

A. The Contractor shall furnish the services of an experienced superintendent, who shall be constantly in charge of the installation of the work, together with all skilled workmen, fitters, metal workers, welders, helpers, laborers and the like, required to unload, transfer, erect, connect, adjust, start, operate and test each system.

B. All work shall be done by first-class and experienced mechanics, properly supervised. It is understood that the Owner has the right to stop any work that is not being properly done and has the right to require that any workman, deemed incompetent by the Engineer, be removed from the job and a competent workman substituted therefore.

C. All equipment and material shall be installed in accordance with the recommendations of the manufacturer, unless otherwise specifically indicated on the Drawings or Specifications, or unless otherwise approved by the Engineer. This shall include the performance of such tests as the manufacturer recommends.

3.06 SCAFFOLDING, RIGGING, HOISTING AND CONTROLS

A. The Mechanical Contractor shall provide all construction aids, scaffolds, rigging, staging, ladders, ramps, railings, hoists, cranes, chutes, tools, services, facilities, equipment and the like as required for delivery, erection, and installation of the work.

B. The Mechanical Contractor shall provide and maintain all barriers as required to prevent public entry, and to protect the work, work by others, and areas accepted for substantial completion from construction operations.

C. Remove same from premises when no longer required.

3.07 SAFETY REQUIREMENTS

A. Contractor shall comply with the Owner's general safety rules, including insurance requirements. Contractor shall instruct all of his employees and subcontractors and shall take all practicable measures to enforce compliance with all of the applicable safety and security rules and regulations in and adjacent to these areas, to insure the least possible interruption of or interference with Owner's operations and work by others.

B. The finished installation of all systems and equipment shall be safe, creating no hazard when operating or at rest. All moving parts shall be covered with appropriate guards. All rough edges of equipment and materials shall be made smooth.

C. Applicable OSHA requirements shall be met in full.

3.08 ACCESS AND CLEARANCES

A. The Contractor shall verify the size of shafts and chases, and the adequate clearance in double partitions and hung ceilings for the proper installation of his work. He shall cooperate with the General Contractor and all other contractors whose work is in the same space, and shall advise the General Contractor of his requirements. Such spaces and clearances shall, however, be kept to the minimum size required.

B. The Contractor shall locate all equipment which must be serviced, operated or maintained in fully accessible positions. Equipment shall include but not be limited to sensors, controls, fire dampers, valves, traps, cleanouts, vent and drain points. Access to equipment shall be in accordance with the manufacturer's recommendations and good trade practice.

C. The Contractor shall locate all equipment to avoid conflicts and clearance requirements required by other trades.

D. Locate equipment to maintain clearances required by electrical panels.

E. Equipment access and clearances shall comply with applicable code requirements.

F. Provide access doors in ductwork, equipment, and the like as required for good maintenance and service access.

G. Unless otherwise noted, access doors required in building surfaces shall be provided by the General Contractor. The Mechanical Contractor coordinate exact locations and size of access doors needed for his equipment, valves, controls, or other devices requiring service.

H. Minor deviations from Drawings may be made to allow for better accessibility. Such deviations shall be approved by the Engineer.

3.09 OPENINGS, SLEEVES & FLASHINGS

A. The General Contractor shall provide all duct and pipe openings, chases and shafts in all existing and new construction as specified. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient time for the General Contractor to make the necessary

provisions. The Mechanical Contractor shall be responsible for the correct size and location of each opening for his equipment even though these openings are provided by the General Contractor.

B. The Mechanical Contractor shall arrange for necessary openings in building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, Engineer 's approval shall be obtained before cutting, and portions cut shall be restored to their former condition by this Contractor.

C. The Mechanical Contractor shall provide pipe sleeves to the General Contractor for installation where pipes pass through walls, floors or partitions. Sleeves through partitions and walls shall be 16 gauge minimum steel pipe flush with both sides of walls or partitions, and coated with rust inhibitive paint. Seal piping penetrations thru outside walls and floor for weatherproofing and leak tight.

D. Sleeves for uninsulated pipes shall be large enough to permit expansion movement. Sleeves shall generally be 1" larger in dimension that the outside diameter of the pipe. Coordinate exact clearance requirements for fire stopping as required by data sheets for UL System numbers with General Contractor.

E. Sleeves for insulated pipes shall be large enough to accommodate insulation and to permit expansion movement. Insulation shall be continuous through sleeves. Sleeves shall generally be 1" larger than outside diameter of insulation. Coordinate exact clearance requirements for fire stopping as required by data sheets for UL System numbers with General Contractor.

F. Where smooth, uniform penetrations can be made in existing concrete wall construction by means of core drilling, sleeves shall not be required. However, penetrations made in this manner shall meet all the above requirements for sleeves, such as sizes, clearances, sealing requirements, UL fire stopping, and the like.

G. Where pipes penetrate firewalls, fire partitions, or fire rated floors, U.L. approved fire stop seals shall be provided. Pack all other spaces between sleeves and insulation or pipe with fiberglass to make airtight unless indicated otherwise by U.L. approved installation methods.

3.10 CUTTING AND PATCHING

A. General Contractor shall provide all cutting and patching necessary to install the work specified in this Division. Patching shall match adjacent surfaces, or new finishes as specified.

B. No structural member shall be cut without the specific approval of the Engineer except as specifically detailed on the Drawings. All such cutting and reinforcing shall be done in a manner directed by the Engineer.

C. Cutting and patching of footings after general construction will not be permitted.

D. The General Contractor shall provide all duct and pipe openings, chases and shafts in all existing and new construction. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient

time for the General Contractor to make the necessary provisions. This Contractor shall be responsible for the correct size and location of each opening for his equipment even though these openings are provided by the General Contractor.

E. The Mechanical Contractor shall arrange for necessary openings in building to admit his equipment. If it becomes necessary to cut any portion of building to admit his equipment, Engineer's approval shall be obtained before cutting, and portions cut shall be restored to their former condition by this Contractor.

F. Cutting and patching of roof openings in existing facilities shall be coordinated with the Owner. If required to maintain bonded warranty, this work shall be performed by the bonding agent. Verify specific requirements for maintaining warranty for the existing roof with the Owner.

3.11 FIRE STOP SEALS

A. The General Contractor shall provide all fire stopping for pipe and conduit thru penetrations thru existing and new fire rated floors, partitions, and walls. The Mechanical Contractor shall advise exact dimensions, shape, and locations of openings required in sufficient time for the General Contractor to make the necessary provisions and shall be responsible for the correct size and location of each opening.

B. Fire stop seals shall be installed in strict accordance with the UL Fire Resistance Directory and the manufacturer's recommendations and data sheets for each type of opening or void.

C. Fire stop seals shall be an intumescent material capable of expanding up to 10 times when exposed to temperatures beginning at 250^{o}F. All fire stop systems shall be UL Classified and have ICBO, BOCAI, and SBCCI (NER 243) approved ratings to 4 hours for floor penetrations and 2 hours for wall and partition penetrations per ASTM E-814 (UL 1479). Manufacturer shall be 3M, or equal by Dow Corning.

D. All surfaces that will be in contact with the penetration seal materials shall be cleaned of dirt, grease, oil, loose materials, rust, or other substances that may affect the proper fitting and adhesion of the installed sealant materials. Surfaces shall be smooth and without gouges or other irregularities.

E. Protect materials installed to seal fire rated penetrations from damage where installed on surfaces subject to traffic.

F. Verify thorough penetration seals by inspection of installed materials. Provide for accessibility to penetration seals for inspection by applicable code authorities.

3.12 VIBRATION ISOLATION

A. All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer.

B. For moving machinery, sound or vibration noticeable outside of the room in which it is installed, or annoyingly noticeable inside its own room, will be

considered objectionable.

C. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at the Contractor's expense.

3.13 PROTECTION

A. Contractor shall protect all work and material from damage, and shall be liable for all damage during construction.

B. Contractor shall be responsible for work and equipment until all construction is finally inspected, tested, and accepted. He shall protect work against theft, injury or damage; and shall carefully store material and equipment received on site which are not immediately installed. He shall close open ends of work, including ductwork, pipe and equipment, with temporary covers or plugs during storage and construction to prevent entry of obstructing materials.

C. Contractor shall be responsible for the Owner’s existing facilities and equipment during construction and testing of new work and equipment provided under this project. Contractor shall protect existing facilities and equipment against theft, injury, or damage.

D. See the Contract Documents, including the General Conditions, Supplementary General Conditions and General Requirements.

E. During construction, cover open ends of air handling units and ducts with 6 mil polyethylene secured with duct tape.

3.14 HOUSEKEEPING AND CLEANING

A. Refer to General Conditions and Supplementary General Conditions.

B. Maintain the work site and surrounding areas reasonably clean and free of dirt, debris, waste and surplus materials.

C. Maintain clean and safe working conditions.

D. Daily: During construction, execute daily cleaning to keep the work, the site and adjacent properties free from accumulations of waste materials, rubbish and windblown debris, resulting from construction operations.

E. Waste Containers: Provide on-site containers for the collection of waste materials, debris and rubbish.

F. Waste Removal: Remove waste materials, debris and rubbish from the site periodically and dispose of at legal disposal areas away from the site.

G. Dust Control: Schedule operations so that dust and other contaminants resulting from work will not interfere with other operations.

H. Final Cleaning:

1. Employ skilled workmen for final cleaning.

2. Remove grease, mastic, adhesive, dust, dirt, stains, fingerprints, labels, and other foreign materials from sight-exposed interior and exterior surfaces.

3. Chrome plated fittings, fixtures, piping and trim shall be polished upon completion.

4. Prior to final completion, Contractor shall conduct an inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that the entire work is clean.

3.15 PAINTING

A. Touch up, or repaint completely, equipment on which factory paint has been damaged. Paint all miscellaneous support steel exposed to weather or visible within an occupied space or mechanical room. Painting materials and methods shall be as specified under the Specification Division and Section titled "Painting".

B. Provide one coat of standard shop primer on all uncoated steel supports, hangers, and components. In addition to primer coat, provide two coats of exterior paint for outdoor or locations exposed to humid conditions.

C. Provide one coat of standard shop primer and two coats of paint where scheduled or specified for piping to be painted.

D. Primer: Standard shop primer equal to Steel Structures Painting Council (SSPC) Specification No. 13. Total dry film thickness shall be not less than 2.5 mils. Verify compatibility of primer with specified finish paint. All miscellaneous steel supports provided for equipment, piping, and accessories furnished shall be fully coated with approved shop primer paint. Uncoated, bare steel supports will not be accepted.

E. Paint: Paint shall be weather resistant high-gloss exterior enamel for use over primed surfaces. Paint shall be Glidden 4500 Glid-Guard Industrial Enamel or equal by Moore or Duron.

3.16 ASBESTOS CONTAINING MATERIALS (ACM): Every effort has been made by the Owner to identify and remove any to ACM from the existing facility prior to the start of Contractor work. The Contractor is responsible for notifying the Owner upon discovery of any materials which the Contractor suspects may contain asbestos. The Owner wil arrange for testing and removal of any ACM. The Contractor shall schedule his or her work in such a manner that minor interruptions for ACM removal will not constitute work stoppages.

3.17 RECORD DOCUMENTS: Contractor shall maintain at the project site one complete set of red-marked Contract Drawings and Specifications, continuously updated as the work progresses, to show all changes to the work and indicate actual installation of equipment and systems. Where deviations from scheduled equipment are provided, these deviations shall be indicated on updated and marked schedules.

3.18 PLACING IN SERVICE

A. Before being placed into operation, each item of equipment shall be serviced in accordance with the requirements of these Specifications and the manufacturer's recommendations. This servicing shall include alignment, lubrication, instrument liquids, instrument and control calibrations and adjustments, testing and adjusting of operating controls.

B. Ducts, plenums and casings shall be cleaned of all debris and blown free of all particles of rubbish and dust before startup.

C. Piping shall be continuously flushed with clean water until flushing water leaving the piping runs clean. Flushing shall be done at sufficient velocity to ensure proper cleaning. Refer to piping Specifications for additional cleaning requirements.

D. Motors shall be "bumped" to assure proper rotation.

E. Alignment of all shafts, couplings, pulleys, belts and the like, shall be verified.

3.19 TESTING AND BALANCING: Provide complete testing and balancing of all systems and equipment, as specified in separate section of this Specification Division.

3.20 OPERATIONAL TESTS AND SERVICING

A. In addition to testing and balancing specified elsewhere in this division of the Specifications, the Contractor shall make all tests, trial operation balancing and balance tests, and the like, as specified and as directed by the Engineer to prove that all work under these Drawings and Specifications is in complete serviceable condition and will function as intended. All costs of tests shall be borne by Contractor.

B. Pulley sizes and belts shall be adjusted or changed as necessary to obtain the specified performance.

C. All controls, valves and equipment shall be adjusted to settings indicated.

D. At the completion of performance runs, the Contractor shall recheck all equipment and verify that each item is functioning correctly.

E. Upon completion of all work, each system shall be tested to determine if detection of objectionable noise or vibration is apparent during operation of the system. If any such objections are detected in the system or equipment, the Contractor shall be responsible for correcting the problem.

F. Bearings shall be re-lubricated as recommended by the equipment manufacturer.

3.21 ACCEPTANCE OF EQUIPMENT

A. The Contractor shall schedule field observation of all pressure tests, leak tests, equipment factory start-ups, and similar tests requiring field observation by the Engineer.

B. The Contractor shall schedule all inspections with the Engineer at least 48 hours prior to the time of inspection. Inspections shall be scheduled prior to

backfilling, and installation of ceilings, walls, or other work that would hinder access.

C. In the event that the Owner considers it impractical, because of unsuitable test conditions or some other factor, to execute simultaneous final acceptance of all equipment, portions of the installation may be certified by the Engineer for final acceptance when that portion of the system is complete and ready for operation.

D. The Contractor shall cooperate in making corrections to deficient work. If an unreasonable number of inspections are required by the Engineer as a result of the Contractor's failure to make corrections previously noted, the Contractor shall be responsible for the cost of such inspections. The cost of these inspections shall be based on the Engineer's hourly rate plus travel expenses.

3.22 FINAL CLEANING

A. Employ skilled workmen for final cleaning.

B. Remove grease, mastic, adhesive, dust, dirt, stains, fingerprints, labels, and other foreign materials from sight-exposed interior and exterior surfaces.

C. Chrome plated fittings, fixtures, piping and trim shall be polished upon completion.

D. Prior to final completion, Contractor shall conduct an inspection of sight-exposed interior and exterior surfaces, and all work areas, to verify that the entire work is clean.

3.23 TRAINING

A. Contractor shall schedule operation and maintenance training with the Owner. Provide written notice to the Owner of such training to confirm scheduling.

B. Instruct Owners' operators in proper operation and maintenance of all equipment and controls. Supervise the operation of the system until the Owners' operators are familiar with the equipment and controls. See other Specification Sections for additional requirements.

3.24 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Submit in within 30 days of shop drawing approval complete descriptive information, operating and maintenance instructions and spare parts lists for all equipment installed under this contract. All information shall be assembled in three ring binders with index tabs to identify each item of major equipment and each system.

B. Provide title sheet with job name, and the names, addresses and phone numbers of the Contractor, subcontractor, control subcontractor, related contractors, and material and equipment suppliers.

C. Each manual shall be self-contained and include information for efficient servicing of equipment supplied and installed under the contract.

D. Operating instructions shall explain maintenance procedures, methods of checking the systems for safe and normal operation, and the recommended procedure for safely stopping and starting the equipment and/or system.

E. Instruct Owner's personnel in proper operation and maintenance of all equipment and controls.

F. These requirements shall be fulfilled before any guarantee periods become effective so as to limit the possibility of claims arising from the absence of pertinent information.

3.25 CONTRACT CLOSEOUT SUBMITTALS

A. All record documents and close-out submittals shall be completed satisfactorily before final application for payment will be approved.

B. Evidence of compliance with requirements of governing authorities shall be submitted.

C. Provide one complete set of Contract Drawings and Specifications marked in red with all changes to the work to indicate actual installation.

D. Provide one complete set of Record Submittal Drawing prints marked in red with all changes to the work to indicate actual installation. These records are a specific contract requirement, and final payment will not be made until these Drawings and Specifications have been submitted in an acceptable form.

E. Operating & Maintenance Manuals: Submit as indicated in Division 1.

F. Testing & Balancing Reports: Submit as indicated in Division 1.

G. Guarantees, Warranties and Bonds: Submit as indicated in Division 1.

H. Spare parts and maintenance materials: Submit as indicated in Division 1.

I. Manufacturer’s startup reports: Submit as indicated in Division 1.

J. Inspection and Test Reports: Submit as indicated in Division 1.

K. Statement of payment of taxes: Submit as indicated in Division 1.

L. Affidavit of Payment of Debts and Claims: Submit as indicated in Division 1.

M. Affidavit of Release of Liens: Submit as indicated in Division 1.

END OF SECTION

SECTION 23 00 20
MECHANICAL DEMOLITION

PART 1 - GENERAL

1.01 WORK INCLUDED:

A. Work of this section includes demolition and removal of existing HVAC and piping materials and equipment shown on Demolition Drawings, and as necessary to complete the required construction. The required demolition includes, but is not limited to the following:

1. Protection of existing building equipment and fixtures as required to complete the work.

2. Removal of miscellaneous pipes, equipment, conduit, and controls associated with existing HVAC equipment. (Demo of electrical wiring shall be by Electrical Contractor.)

3. Removal and disposal offsite of all debris resulting from the demolition.

4. Protection of the Owner's existing building, pavement, remaining utilities, landscaping, and equipment throughout the work.

5. Protection of, and coordination with, Owner's on-going usage. Maintain egress/access at all times.

6. Protection of existing structural members.

7. Maintaining the building weathertight during demolition and construction.

8. Maintaining the building secure during demolition and construction.

B. Obtain any required permits and comply with all local ordinances for demolition work.

C. Provide all guardrails, barricades, and other safety measures.

D. Provide temporary partitions for noise and dust controls. Partitions are to remain in place throughout the construction period. Partitions are to be constructed using metal studs and drywall.

E. Clean-up of work areas on a daily basis.

F. Repair wall penetrations where ductwork, and/or piping is removed during demolition.

1.02 SUBMITTALS:

A. Submit a copy of all permits and certificates required for work of this section.

B. Submit demolition procedures and operational sequence for review and acceptance by the Owner. These procedures shall include the following:

1. Description of methods and procedures for protecting the existing building, equipment, fixtures, etc.

2. Description of methods and procedures for maintaining the building watertight during the construction.

1.03 PROTECTION:

A. Safety measures and methods shall be used to protect personnel and property to remain undisturbed.

B. Do not interfere with use of the building's operation except as approved by the Owner.

C. Provide and place bracing or shoring and be responsible for safety and support of remaining construction. Assume liability for such movement, settlement, damage, or injury.

D. Cease operations and notify the Owner immediately if safety of remaining construction appears to be endangered. Do not resume operations until safety is restored.

E. Use approved methods (including partitions with gypsum board covering) to provide dust control during demolition.

F. Provide protection to adjacent areas where work is in progress.

G. Provide temporary dewatering as required to accomplish specified construction.

H. Locate and deactivate all utilities prior to commencing demolition. Protect existing utilities to remain.

1.04 EXISTING SERVICES: If requested, the Owner may disconnect utility services. Any temporary disconnection of the utility services, prior to removal of the services in sections to be demolished, shall be planned and authorized by the Owner. Disruption to existing utilities, if approved, is to be held to absolute minimum time period. Interruption of existing utility services shall be scheduled with the Owner at least one week in advance.

1.05 JOB CONDITIONS:

A. Condition of Structures: The Owner or Engineer assume no responsibility for the actual condition of areas to be demolished.

1. Bidders for this work shall make such investigation as they deem necessary to arrive at the cost of this portion of the work. No extras will be paid for hidden conditions not indicated or expected.

2. Conditions existing at the time of inspection for bidding purposes will be maintained by the Owner in so far as practicable.

B. Inspection: The Contractor shall inspect the site to determine the extent of demolition work that will be required prior to submittal of bid. Demo drawings may not indicate all demolition required to complete the required construction.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Materials, equipment, and the like which are to be salvaged shall be removed in an approved manner. Deliver salvaged materials, equipment, and the like to the Owner's designated location.

B. Materials or parts of structures, not specifically specified on Drawings or designated by Owner to be salvaged, shall be properly disposed of at locations off the job site.

C. Repair existing openings to match adjacent materials and finishes where ductwork, piping, and equipment is removed.

PART 3 - EXECUTION

3.01 PREPARATION:

A. Erect weatherproof and secure closures for exterior openings. Maintain exit requirements.

B. Erect and maintain dustproof partitions as required to prevent spread of dust, fumes and smoke to other parts of the building. On completion, remove partitions and repair damaged surfaces to match adjacent surfaces.

C. Carry out demolition work to cause as little inconvenience to adjacent occupied building areas as possible.

D. Construct protective enclosures around all equipment to remain.

3.02 DEMOLITION:

A. All demolition shall be performed in accordance with applicable codes and regulations of authorities having jurisdiction.

B. Demolish in an orderly and careful manner as required to accommodate new work and to suit construction phasing. Protect existing structural members and construction to remain.

C. Repair all demolition performed in excess of that required, at no cost to the Owner.

D. Burning of materials on site is not permitted.

3.03 REMOVAL:

A. If not indicated to be salvaged, remove demolished materials, debris, dust, tools and equipment from site upon completion of work. Leave site in a clean condition.

B. Transport all materials removed from demolished area and properly dispose of off-site. No items are to be abandoned in place.

3.04 REPAIR AND REPLACEMENT: Any damage to existing facilities, equipment, structure, or property resulting from demolition or construction by the contractor shall be repaired or replaced by the contractor to the satisfaction of the Owner.

3.05 SALVAGED EQUIPMENT AND MATERIALS:

A. Transport to the Owner's designated location any equipment or materials that are identified to be salvaged and submitted to the Owner.

B. Protect and store any equipment or materials identified to be reused or reinstalled.

END OF SECTION

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES:

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
C. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
D. ANSI/NEMA MG 1 - Motors and Generators.
E. ANSI/NFPA 70 - National Electrical Code.
F. EPAct - U.S. Energy Policy Act of 1992.
G. UL - Underwriters Laboratory.
H. ETL Testing Laboratory
I. CSA - Canadian Standards Association

1.03 SUBMITTALS:

A. Submit product data clearly indicating manufacturer, horsepower, voltage, phase, efficiency, service factor, enclosure type, maximum amps, dimensions, and terminations for each motor.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.04 REGULATORY REQUIREMENTS:

A. Conform to National Electric Code.

B. Motors shall be UL or ETL listed.

C. Motor Efficiency shall meet or exceed the latest requirements of the U.S. Energy Policy Act of 1992.

D. Motors shall be tested in accordance with standards of ANSI/NEMA MG1 and conform to the standard’s requirements for sound power, insulation resistance and dielectric strength.

E. Motors shall be designed for continuous operation in 40 degrees C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor, and motor enclosure type.

1.05 WARRANTY: Contractor shall provide one year warranty from date of final inspection and acceptance.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS:

A. Motor enclosure type, horsepower, RPM, and efficiency type shall be as scheduled on the Drawings.

B. Motor Sizing: Motors shall be sized to not overload or exceed nameplate horsepower (without including service factor) under any conditions of operation of the driven equipment. Motors shall be at least the horsepower indicated or specified.

C. Variable Frequency Drive Motors: Motors for use with variable speed drives shall be sized and insulated for proper continuous duty operation within the manufacturer's rated temperature limitations at all operating speeds and loads.

D. Nameplates: Each motor shall have a visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.

E. Connection Boxes: Motors shall include conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame.

2.02 ACCEPTABLE MANUFACTURERS:

A. Premium Efficiency (Three Phase):

1. Baldor Super E Series
2. General Electric Energy Saver Series
3. Lincoln Electric Energy Efficient Series
4. Reliance XE Series
5. Magnetek (Century) E-Plus III

2.03 THREE PHASE POWER - SQUIRREL CAGE INDUCTION MOTORS:

A. Motors shall be premium efficiency squirrel cage induction type, NEMA Type B or better, three phase, 60 Hz, continuous duty, 40 F ambient, with 1.15 service factor and grease lubricated bearings.

B. Insulation Requirements:

1. Constant Speed ODP Motors: NEMA Class B or better.

2. TEFC, Mill and Chemical, or Explosion-Proof Motors: NEMA Class F.

3. Motors for Variable Frequency Drives: NEMA Class F or better. Insulation shall comply with the requirements of the VFD manufacturer.

C. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

D. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

2.04 SINGLE PHASE POWER - SPLIT PHASE MOTORS:

A. Starting Torque: Less than 150 percent of full load torque.

B. Starting Current: Up to seven times full load current.

C. Breakdown Torque: Approximately 200 percent of full load torque.

D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.

E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.05 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS:

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.06 SINGLE PHASE POWER - CAPACITOR START MOTORS:

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated ball bearings.

G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.07 DISCONNECT SWITCHES: Provide disconnect switches for each motor provided under this Specification Division unless specifically indicated as furnished by the Electrical

Contractor.

2.08 MOTOR STARTERS: Starters not included as an integral part of equipment or specifically indicated to be provided by the Electrical Contractor, shall be furnished by the Mechanical Contractor and installed by the Electrical Contractor for all motors provided under this Specification Division.

PART 3 - EXECUTION

3.01 APPLICATION:

A. Motors drawing less than 600 Watts and intended for intermittent service may be proprietary to equipment manufacturer and need not conform to these Specifications.

B. Motors shall be open drip-proof type, except where specifically noted otherwise.

C. Single phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.

D. Motors located in exterior locations shall be totally enclosed type.

3.02 MOTOR EFFICIENCY: Minimum required full load nominal motor efficiency for three phase motors shall comply with NEMA Premium Efficiency Motor Standards Publication MG-1.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 PIPING SYSTEMS: Supports and anchors for piping systems shall be in accordance with ANSI B31.1, "Power Piping" to maintain required pitch of lines, prevent vibration and provide for expansion and contraction movement.

1.03 REFERENCES:

A. ASME B31.1: "Power Piping"
B. MSS SP-58: "Pipe Hangers and Supports - Materials, Design and Manufacture"
C. MSS SP-69: "Pipe Hangers and Supports - Selection and Application"
D. MSS SP-89: "Pipe Hangers and Supports - Fabrication and Installation Practices"

1.04 QUALITY ASSURANCE:

A. Materials and fabrication procedures shall be subject to inspection and tests in mill, shop, and at the site. Test shall be conducted by a qualified inspection agency employed by the Owner.

B. Such inspections and tests shall not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.

C. Contractor shall promptly remove and replace materials or fabricated components which do not comply with requirements of Contract Documents.

D. Welded construction shall comply with AWS Code for procedures, appearance, and quality of welds and for methods used in correcting welding work.

1.05 SUBMITTALS:

A. Submit shop drawings in accordance with Section 23 00 10 - Mechanical General Provisions.

B. Submittals shall be provided for hanger and support types according to pipe size, pipe service type, and exposure classification.

C. Submittals shall include manufacturer's product data, protection saddle product sheets, coating/finish product data sheets, and fabrication

drawings necessary to confirm compliance with specified hanger types and details on the Drawings.

D. Submittals are required for all fabricated materials and assemblies to be

furnished and delivered to the site.

E. Welded connections shall be indicated with standard AWS symbols (showing size, length, and type of each weld).

F. Submit coordination drawings in accordance with Section 23 00 10 - Mechanical General Provisions. Drawings shall also include the following:

1. Location and type of each hanger and support.

2. Total loads of pipe, fittings, valves, insulation, supports and pipe contents that will be applied at each attachment point to the building structure.

3. Type and/or detail of each attachment point proposed to be used for connection to the building structure.

4. Contractor shall be prepared to demonstrate calculations used to determine loads at each attachment point, upon request by the Engineer.

G. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, the Contractor shall submit a certification stating that such requirements have been complied with.

PART 2 - PRODUCTS

2.01 MANUFACTURERS: Support and hanger products are specified below by reference to Grinnell or Michigan figure numbers. Equivalent products by Bergen-Paterson, Grinnell, B-Line, Corner & Lada, Michigan Hanger Co., Gulf States, F&S Central, Crawford, Modern, or Pipe Shields, Inc. will be accepted.

2.02 MISCELLANEOUS SUPPORT MATERIALS:

A. Rolled Steel Plates, Shapes, and Bars: ASTM A36

B. Cold-Formed Steel Tubing: ASTM A500, Grade B; Fy = 46 ksi

C. Steel Pipe: ASTM A53, Type E, Non Tested, Grade B; Fy = 35 ksi

D. Anchor Bolts: ASTM A36

E. High-Strength Threaded Fasteners: Heavy hexagon bolts, nuts, and hardened washers complying with ASTM A325.

F. Electrodes for Welding: Comply with AWS Code, ASTM A233-E70 Series electrodes.

2.05 SHOP COATING SYSTEMS:

A. Shop Primer and Paint: Refer to Specification 23 00 10.

B. Electro-Plated Galvanized: ASTM B633 SC1 or SC3 coating of zinc on steel by electrolysis from a bath of zinc salts. This coating is pure zinc and adheres to the steel with a molecular bond.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS:

A. Provide all hangers, miscellaneous steel, brackets and attachments necessary to adequately support equipment, ductwork, and piping installed under this Division.

B. All hangers, miscellaneous steel, brackets and attachments shall be connected only to the base building structure. No attachment of any kind shall be made to the roof deck or floor deck metal. Proper expansion anchors may be used through the floor deck metal and into the structural floor above.

C. Hangers shall not be shared by other trades. Each trade shall provide hangers and supports for his work. The use of shared hangers shall be specifically approved by the Engineer.

D. Steel supports and fastening devices shall be of structural quality. Steel supports shall be prime painted before installation. Any primer removed or damaged during installation shall be repainted or touched up with primer after installation.

E. All roof mounted equipment shall be supported and fastened to the structure to comply with wind load requirements designated by the North Carolina Building Code. Mechanical Contractor shall furnish equipment support structural calculations at the request of the Engineer.

F. The Mechanical Contractor shall coordinate closely with the Plumbing Contractor, Electrical Contractor, and Controls Subcontractor to confirm quantities and sizes of all utilities scheduled or required to be supported from the pipe, duct, or equipment supports. The Mechanical Contractor shall furnish locations, spacing, quantities and the like to the General Contractor for coordinating the installation with the structure. Refer to pipe support details for details of the permitted attachment types to the building structure.

G. Concrete inserts required for hanging mechanical or plumbing piping, pipe supports, pipe trapeze hangers, HVAC ductwork, and the like, shall be furnished by the Mechanical Contractor to the General Contractor for installation as construction work progresses. Mechanical Contractor shall be responsible for all quantities of such inserts and for sizing inserts to support the intended load. The Mechanical Contractor shall coordinate closely with the Plumbing Contractor, Electrical Contractor, Controls Contractor, and Fire Protection (Sprinkler) Contractor to confirm quantities and sizes of all utilities scheduled or required to be supported from the pipe, duct, or equipment supports. The Mechanical Contractor shall furnish locations, spacing, quantities and the like to the General Contractor for coordinating the installation with the structure. Refer to Structural Drawings for details of the permitted attachment

types and locations respective to the building structure.

3.02 SUPPORT AND ATTACHMENTS:

A. Material and finish for hangers and supports shall be the same as the hanger type required for each location in the project.

B. Where pipe cannot be suspended from overhead supports, use substantial cast iron or welded steel wall brackets or trapeze supports to support the hangers, pipe seats, or roll stands, as conditions demand and as approved by the Engineer.

C. Construct fabricated supports and brackets of structural grade miscellaneous steel and fasteners. Black or plain steel components, which are not specified to have a special finish, shall be delivered to the job site with a prime coat of paint. Touch up primer after fabrication and after installation. All exposed miscellaneous support steel shall, as a minimum, be prime coated with paint to minimize the potential for rusting.

D. Provide all miscellaneous steel, bridging, brackets, anchors, frames, bracing, plates, bolts, nuts, washers, and the like, necessary to properly support piping. All steel, hangers and attachments shall be mounted to the building structural steel frame, concrete or masonry walls, structural concrete floors or concrete structural members.

E. No attachments of any kind shall be made to the roof deck metal or cellular roof deck unless approved in writing by the Engineer. No attachments of any kind shall be made to lateral cross bracing between trusses unless approved in writing be the Engineer.

F. Attach hangers to structure using mechanical anchors rated for not less than two times the calculated hanger load.

G. Material and finish for all components shall be same as the hanger type required for each location.

H. Provide bracing and supports for all vertical pipe risers, with riser clamps at each floor level.

I. All attachments, supports and hangers shall be aligned with the building structure. Hangers rods shall be installed vertically. Arrangement and fabrication of all supports is subject to Engineer's approval. Skewed or bent hanger materials shall be straightened or replaced.

J. Solid or perforated strap hangers and wire hangers will not be permitted, except for temporary supporting during construction.

K. Each trade shall provide hangers independent of other trades. Ceiling grids, piping, ductwork, electrical and communication conduit, equipment, and the like shall all be supported independently.

3.03 WELDED ATTACHMENTS:

A. All welded type support components shall be in accordance with MSS SP-58.

B. All attachments welded to the pipe shall be in accordance with MSS SP-58. Attachments welded directly to the pipe shall be compatible with the chemical composition of the pipe material and the process of attachment shall conform to the requirements for fabrication of the pipe with regards to preheating, welding, and stress relieving.

C. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of AISC Specification for the Design, Fabrication, and Erection of Structural Steel Buildings.

D. All welds shall be performed by certified welders in compliance with the welder's qualifications as specified in Section 23 00 10 - Mechanical General Requirements.

E. Repaint all existing or new building steel where the paint is scraped or burned away during welding operations to match existing paint finishes.

3.04 PRIMING AND PAINTING:

A. All metal surfaces on carbon steel supports, anchors and seals indoors shall be primed.

B. All metal surfaces on carbon steel supports, anchors, and seals exposed to outdoor conditions shall be hot dipped galvanized.

C. Immediately after surface preparations, apply shop paint in accordance with manufacturer's printed instructions, and at a rate to provide a uniform dry film thickness as specified.

D Use painting methods that will result in full coverage of joints, corners, edges, finished welds, and all surfaces.

E. Painting materials and methods shall comply with Specification 23 00 10.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES:

A. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.
B. ANSI Z53.1 - Safety Color Code for Marking Physical Hazards.

1.03 SUBMITTALS: Submit shop drawings in accordance with Section 23 00 10. Submittals shall include, but not be limited to, the following:

A. Legend, list of wording, abbreviations, symbols, letter size, and color-coding for all mechanical identification.
B. Pipe identification; including color scheme, size, color field and legend.
C. Valve chart and schedule; including valve tag number, location, function.
D. Valve tags showing material, size, lettering and attachment.
E. Stencils and stencil paint.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS (Identification Markers and Components):

A. Almetek Industries
B. Brady USA, Inc.
C. Craftmark Identification Systems
D. Panduit Corporation
E. Seton Name Plate Company

2.02 MATERIALS:

A. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background color.

PART 3 – EXECUTION

3.01 PREPARATION:

A. Degrease and clean surfaces to receive adhesive or paint for identification materials.

B. Install identification system items prior to final inspection.

C. Where piping and other surfaces are specified to be painted, install identification system after painting has been completed.

3.02 INSTALLATION:

A. Plastic Nameplates: Install with stainless steel or cadmium plated screw, bolt, or rivet. Adhesive fastening shall not be used.

B. Metal Tags: Install with brass or stainless steel corrosive-resistant chain.

C. Equipment: Identify all equipment with plastic nameplates. Small devices, such as in-line pumps, may be identified with metal tags.

D. Controls: Identify control panels, control components outside panels, and control junction boxes with plastic nameplates.

E. Valves: Identify valves in main and branch piping with metal tags.

F. Piping: Identify piping, concealed and exposed, with stencils. Metal tags may be used on small diameter piping. Identify service and flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 30 feet apart on straight runs including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure, at each obstruction, and at each item of equipment and control.

G. Access Doors: Provide plastic nameplate at or on each access door identifying item or items behind door, such as valve, air vent, drain, and the like.

H. Provide metal ceiling tacks with ¾" diameter color coded head on ceiling grid where HVAC isolation valves are installed above.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES: (Latest edition for listed references shall apply.)

A. ASHRAE Handbook - Fundamentals (latest edition): Chapter. 7 - "Sound and Vibration Fundamentals", and Chapter 13 - "Measurement and Instruments".
B. ASHRAE Handbook - 1991 HVAC Applications: Chapter. 34 - "Testing, Adjusting, and Balancing".
C. ASHRAE Standard 111-1988: "Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems".
D. AABC - "National Standards for Total System Balance, 4th edition".
E. NEBB - "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".
F. SMACNA - "HVAC Systems - Testing, Adjusting & Balancing"
G. SMACNA - "HVAC Air Duct Leakage Test Manual"
H. SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"

1.03 ACCEPTABLE TEST AND BALANCE CONTRACTORS: Acceptable Test and Balance Contractors shall be as follows:

A. Air Balance Corporation of Greensboro, NC
B. Phoenix Agency of Winston Salem, NC
C. Test and Balance Corporation of Winston Salem, NC
D. Joseph M. Gamewell Associates of Salisbury, NC
E. Mid Atlantic Test and Balance of South Boston, VA.
F. Envirotrol of Greensboro, NC.
G. Others as approved in writing by the Engineer

1.04 SUBMITTAL REQUIREMENTS:

A. Submit four (4) typed copies of proposed test procedures for approval in accordance with shop drawing requirements of Section 23 00 10 - Mechanical General Provisions. Include description of procedures, instruments and equipment to be used, catalog data on instrumentation, planned manpower required, and proposed schedule. Provide this information for each type of test, and for each system to be tested. Tests will be specific for the equipment and systems on this project. A complete, blank test sheet shall be provided for each equipment type and test requirement.

B. Submit four (4) typed copies of test schedules of readings taken during testing and balancing operations, indicating the required reading, the first reading taken, and the final balance reading for the items listed in Part 3 - Execution, of this section in accordance with shop drawing requirements of Section 23 00 10 - Mechanical General Provisions. Readings shall be taken with clean operating strainers and filters in place, but with start-up strainers removed.

C. Submit instrument calibration report along with the test schedules of readings taken during testing and balancing operations.

D. Submit Component Deficiency Report(s) as required to provide information helpful in determining the cause of the problem(s) and to provide feedback to the equipment manufacturer, designer, or installer. Submit such reports as soon as the problem becomes evident, before proceeding with remaining related work, and, where practical, provide recommendations for correcting the apparent system component failure. Furnish documentation of confirming test data and observations as required to substantiate the reported problems.

E. All information shall be assembled in a three-ring binder with index tabs to identify each item of major equipment and each system.

1.05 SCOPE OF WORK:

A. SYSTEM PREPARATION, START-UP, INITIAL TESTING AND PLACING IN SERVICE shall be performed by the Mechanical Contractor. The Mechanical Contractor shall be responsible for performing initial equipment and system checks and system start-up in order to prepare the system(s) for testing, adjusting, and balancing by the independent Testing and Balancing (TAB) Contractor. The Mechanical Contractor shall furnish specific project information to the TAB Contractor, including, but not limited to, the following: Two (2) sets of all submittal data, complete shop drawings, duct and pipe fabrication or layout drawings, contract drawings, project specifications, controls system(s) shop drawings, and initial system testing reports for use by the TAB Contractor.

B. SYSTEM TESTING AND BALANCING shall be performed by an independent Testing and Balancing (TAB) Contractor who specializes in the practice of testing, adjusting and balancing of mechanical equipment and systems. The TAB Contractor shall be AABC or NEBB certified.

C. The TAB Contractor shall perform a pre-construction review of the Contract Documents in order to become familiar with the project. TAB Contractor shall advise the Mechanical Contractor regarding potential problems that may impact TAB services and submit a written report to be routed as a shop drawing. The TAB Contractor shall also be available to observe construction progress to identify and minimize TAB or operation problems, witness and certify Contractor's leak tests and manufacturer's performance tests as required.

D. The TAB Contractor shall test existing systems noted herein and provide a report for the existing equipment.

E. The TAB Contractor shall test, adjust and balance all systems until design function and operation are achieved. All work shall be performed in strict accordance with appropriate sections of the AABC or NEBB Standards, the ASHRAE Handbooks, and these Specifications.

F. COMMISSIONING REQUIREMENTS: The TAB Contractor shall provide full time on-site support to commissioning authority in TAB validation. Refer to Specification Section 23 08 00, Mechanical Commissioning Requirements for additional requirements.

G. The TAB Contractor shall participate in the instruction and training of the Owner's operating personnel. The TAB Contractor shall correct any deficiencies for a period of one year following substantial completion and Owner acceptance of final balancing reports.

1.06 SEASONAL TESTING REQUIRED: Testing and balancing of all systems and equipment shall be performed at full load, during seasonal operating periods as required to obtain complete data for all equipment. Testing and balancing shall be repeated during different outdoor conditions as required to verify, test, and report equipment operating capacity at design conditions.

1.07 INSTRUMENTS:

A. The following instruments shall be furnished by the TAB Contractor for the purpose of performing systems testing and adjusting as specified in this section. Instruments required shall include, but not be limited to, the following:

1. Electrical: Digital volt, ohm, clamp-on amp, 1/2% accuracy
   Digital Wattmeter

2. Air: Alnor velometer (optional if Shortridge Velprobe is used)
   Micromanometer - Shortridge electronic with velocity probe and grid.
   8", 18", 36" and 60" ASME pitot tubes
   1/4" oil filled manometer (0-1" inclined)
   Shortridge or Alnor balancing cones
   Aspirating smoke generator
   Pressure fan for leak testing
   Superior Smoke bombs

3. RPM: Stroboscope: Digital - 1% $\pm$ RPM accuracy
   Digital tachometer: 1% $\pm$ RPM accuracy

4. Water: -30" Hg to 60 psi pressure gauge 1/2% accuracy
   0 to 200 psi pressure gauge 1/2% accuracy
   0 to 36" Hg manometer
   0-200' digital differential pressure meter

5. Temperature: Digital thermometer 1/10^{o} resolution, 1% accuracy

   Surface and immersion probes for thermometer
   Wet-bulb wicks and fans

6. Thermometer: 30 to 120^{o} 0.2^{o} 16" mercury

7. Air Quality: CO_2 analyzer

8. Noise: ANSI Type 1 meter w/octave band analyzer

9. Vibration: IRD or equal w/octave band analyzer

B. All meters shall be checked and calibrated with primary instruments prior to beginning any tests on this project. Voltmeters and other instruments that

cannot be checked shall be laboratory calibrated at reasonable intervals of not more than one year. Magnehelic or dial type differential pressure gauges may be used only for preliminary or non-certified work with their ranges, after calibration using the fluid filled manometers.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.01 TESTING, ADJUSTING AND BALANCING (GENERAL):

A. The Contractor shall engage the services of an independent TAB Contractor who specializes in the practice of testing, adjusting and balancing mechanical equipment and systems. Testing Contractor shall test, adjust and balance all systems until design function and operation are achieved.

B. TAB Contractor shall demonstrate performance of design function and operation for each system to the Engineer.

C. Testing, adjusting and balancing shall be performed in accordance with the recommended procedures of the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).

D. Perform testing specified in this section in the presence of the Engineer. Local or state authorities having jurisdiction shall be given due notice of the tests as may be required by them, and acceptance of the work by the Engineer will be contingent upon acceptance by the public authority.

E. All system equipment shall be inspected, adjusted, and tested after installation. Adjustments shall be made and tests shall be repeated as often as necessary to insure that the equipment operates as specified.

F. Furnish all necessary equipment and assume all costs involved to perform all testing and balancing.

G. Tests of piping systems shall be conducted before connections to equipment are made, and before piping is insulated and/or concealed.

H. Systems found to have leaks shall be retested after leaks have been repaired.

I. The TAB Contractor shall cooperate with the Mechanical Contractor, Controls Contractor, and Commissioning Agent in performing all testing required and adjustments needed to achieve intended system performance.

J. Balancing of each system shall not be done until the system has been completed and is fully operational. Where manufacturer's startup is required, balancing shall be performed after manufacturer has certified that startup is complete.

K. Unless noted otherwise, take all balancing readings with clean strainers and filters in place.

L. Instruments shall be calibrated prior to balancing. Types, serial numbers, and

dates of calibration of all instruments shall be listed in the final balance reports.

M. After cleaning and testing of individual equipment items, test each system to determine that all items perform as integral parts of the system. Make corrections and adjustments to produce the specified conditions.

N. The Contractor shall make any changes in pulleys, belts, motors, dampers and valves, and add any dampers and valves, as required for achieving correct air and water balancing.

O. Equipment provided with variable frequency drives shall be balanced at 100% speed to allow drive operation in the bypass mode (maintenance, servicing, etc.).

P. Contractor shall maintain records of all inspections and tests performed on all systems. Records shall indicate which systems were tested, date of test, test witness, test conditions (be specific), test pressure and duration, test results, weather conditions, visual inspections, percent of system installation completed at time of test, specific test observations, and pertinent statements for the purpose of qualifying results or observations and number of tests required to achieve a successful test.

Q. The final test and balance report shall include as a minimum, all data indicated in test schedules included herein. Also, include records of inspections and tests in the final project documentation.

3.02 DUCTWORK AND AIR HANDLING EQUIPMENT TESTS: (Start-up and Placing in Service)

A. Inspect all main duct systems as work progresses. Smoke test the entire system if the leaks are apparent. Seal all duct joints with specified sealants. Visually inspect all air handling units, A/C units, plenums, coil casings, filter boxes, and accessories and the connections to the ductwork systems. Seal leaks and correct mechanical problems as required. Verify that all access doors and panels are gasketed and have operable latches. Outlets or taps shall be covered with plastic during testing.

B. Adjust belts and align drives for all rotating equipment. Lubricate bearings, dampers, etc., and check systems for excessive vibration and noise levels. Make adjustments necessary to prepare systems for final testing and balancing.

3.03 DUCTWORK LEAKAGE TESTS

A. Test ductwork as work progresses in accordance with SMACNA "Air Duct Leakage Manual: with all handling equipment, connecting ductwork, dampers, accessories and air outlet and inlets in place.

B. Test pressure shall be equal to the specific duct pressure class rating, except smoke exhaust ductwork which shall be pressure tested to 1.5 times design pressure with less than 5% leakage in accordance with Building Code Section 909.10.2.

C. Perform duct leakage tests for all ductwork and submit test reports to Engineer.

3.04 DUCTWORK SYSTEMS ADJUSTING AND BALANCING:

A. In cooperation with the Mechanical Contractor, the Controls Contractor, Owner, and Engineer, set adjustment of controls to operate as specified.

B. Adjust fan speeds, duct systems and components to provide air quantities within $\pm$ 5 percent of specified requirements under minimum and maximum flow conditions at each air inlet, outlet and variable air volume terminal unit.

C. Measure air quantities in main and branch ducts by traversing cross sectional area of duct with pitot tube. Ducts having minimum velocities of 1000 feet per minute or more shall be measured with inclined manometers (draft gage) or magnehelic gages. Ducts having velocities of less than 1000 feet per minute shall be measured with micromanometers, hook gages, or similar low pressure instruments. Openings in ducts for pitot tube insertion shall be accomplished by installation of instrument ports. When not in use, ports shall be sealed with plastic "snap-plugs". Diffuser, grille, and register air quantities shall be determined by direct reading velocity meters.

D. Obtain design air quantities in main ducts by adjusting fan speeds. Then adjust branch duct air quantities by volume or splitter dampers.

E. After testing and adjusting branch ducts, terminal units, grilles, and the like, retest main duct air quantities. Re-adjust if required.

F. Permanently and legibly scribe, punch, or paint mark dampers after air balance is complete to enable them to be restored to their correct position if disturbed at any time.

G. Test fire dampers to prove that they open and close properly.

3.05 CONTROL SYSTEMS ADJUSTING AND BALANCING:

A. In cooperation with the Mechanical Contractor, the Controls Contractor, and Engineer, set adjustment of controls to operate as specified.

B. Adjust and record set points of all control valves, dampers, controls and safeties for each equipment item, such as heat exchangers, pumps, fans, ductwork, valves, and the like, for each system. Coordinate with the Controls Contractor as required.

3.06 AIR HANDLING UNIT ADJUSTING AND BALANCING:

A. Take all balancing readings with filter pressure loss simulated for dirty filters to insure 100% air flow can be achieved with filters dirty. This shall be achieved by partially blocking off a portion of clean filter sections until the differential pressure across filters is equal to the scheduled dirty filter pressure loss.

B. Adjust fan and/or motor pulleys as required to achieve 100% design air flow with fan motor and variable speed drive operating at 100% speed.

3.07 SOUND AND VIBRATION:

A. Perform tests in accordance with ASHRAE guidelines for any equipment where objectionable noise is present. Use an ANSI type 1 or 2 sound level and meter to determine noise levels. Tests shall include readings at octive band levels for each location tested.

B. Measure vibration amplitude of all air handling units and all major rotating equipment.

C. Where excessive noise is caused by unbalanced or misaligned or improperly supported piping or equipment, the Mechanical Contractor shall correct such problems at no additional cost to the Owner.

D. Report equipment or rooms that appear to exhibit "out-of-range" or abnormal noise conditions.

E. Verify that vibration isolation components (hangers, spring supports, vibration pads, and the like) are properly installed, aligned and are not "bottomed-out" or short-circuited by improper contact. Document potential isolator problems for resolution by the Contractor.

3.08 TEST SCHEDULES:

A. General:

1. Provide the data required in Part 1 - General of this section. For each test, record the outside air temperature and humidity during the actual test. List the specified design data, first test reading taken, and final reading for each measurement.

2. Title/Cover Page:

a. Company name
b. Company address
c. Company telephone number
d. Project name
e. Project location
f. Project Architect
g. Project Engineer
h. Project Contractor

3. Instrument List:

a. Instrument
b. Manufacturer
c. Model
d. Serial number
e. Range
f. Calibration date

B. Air Handling Unit Data:

1. Designation, tag number

2. Manufacturer, model and serial number

3. Size

4. Motor hp, volts, cycles, phase, service factor and F.L. amps (nameplate)

5. Design conditions:

   a. Supply air flow, CFM
   b. Outside air flow, CFM (Minimum and Maximum)
   c. External Static Pressure, In. w.g.
   d. Fan RPM
   e. BHP

6. Field tests:

   a. Supply air flow, CFM
   b. Outside air flow, CFM
   c. Inlet Static Pressure, In. w.g. (at each section)
   d. Discharge Static Pressure, In. w.g. (at each section)
   e. Total External Static Pressure, In. w.g.
   f. Static Pressure at each unit section, In. w.g.
   g. Inlet and outlet air Temperature, Deg. F
   h. Fan RPM
   i. Volts/Amps (Each Phase)
   j. Calculated bhp

C. Coils:

1. Designation, tag number

2. Manufacturer, model and serial number

3. Size and type

4. Design conditions:

   a. Air Flow, CFM
   b. Face velocity, fpm
   c. Air Temperature, db/wb, in and out, Deg. F
   d. Air Pressure drop, In. w.g.
   e. Water flow rate, GPM
   f. Water temperature in, Deg. F
   g. Water temperature out, Deg. F
   h. Water pressure drop, Ft.
   i. Capacity, mbh

5. Field tests:

   a. Air Flow, CFM
   b. Face velocity, fpm
   c. Air Temperature, db/wb, in and out, Deg. F
   d. Air Pressure drop, In. w.g.
   e. Water flow rate, GPM
   f. Water temperature, in & out, Deg. F

g. Water pressure drop, Ft.
h. Calculated capacity, mbh

D. Air Balance Test Data:

1. Velocity tests for main and branch ducts and fresh air intake duct; exhaust terminals, and exhaust and supply ducts for all air handling units, packaged units, fans, and the like connected equipment and exhaust terminals:

   a. Duct location and designation
   b. Duct size
   c. Static pressure
   d. Duct average velocity, FPM
   e. Total air quantity, CFM

2. Individual diffusers, registers, and grilles:

   a. Diffuser, register, or grille identification as to location, area, and system
   b. Manufacturer, type and size
   c. Required and resultant test quantities, CFM
   d. Note any specific deficiencies or excessive noise

3. Duct accessories:

   a. Test fire dampers, smoke dampers, and combination fire and smoke dampers to prove that they open and close properly.

   b. Test control dampers to prove that they open and close properly, and verify all max. and min. settings.

E. Sound and Vibration Test Data:

1. Rotating equipment:

   a. Measure vibration amplitude (Peak-to-peak displacement in mils) in accordance with AABC test procedures. Fan wheels shall be both statically and dynamically balanced to provide for vibration displacement of bearing not to exceed the following measurements:

Shaft RPM	(Peak-to-Peak) Mils Displacement
600	2.0
900	1.5
1200	1.0
1800	0.75
3600	0.40

   b. Record dBA by octave band in 25% of the rooms (take readings approximately five feet above the floor on a line 45 degrees from the loudest noise source in the room)

c. List excessively noisy areas and study the situation along with the Engineer and Contractor.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 – GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 INTENT: The intent of this Specification is to provide a quality installation which may not be attainable through the use of a standard composite consisting of insulation, vapor retarder and jacket assembled by an insulation manufacturer. However, in some installations, composites will be acceptable provided they meet the requirements of the Specifications relating to referenced standards for individual components.

1.03 STANDARDS: Insulation products and installation shall, as a minimum, comply with the National Commercial & Industrial Insulation Standards published by the Midwest Insulation Contractors Association (MICA), Omaha, Nebraska, latest edition.

1.04 DEFINITIONS:

A. All-Service-Jacket (ASJ): A white kraft paper bonded to aluminum foil and reinforced with glass fibers. The composite jacket has an integral longitudinal lap with woven glass fabric tape.

B. Concealed Spaces: All areas other than finished spaces which are generally not visible after completion of the project.

C. EPFI: Engineered polymer foam insulation.

D. Finishing Cement: A mixture of various insulating fibers, fillers, and binders with water, with or without hydraulic cement, to form a smooth trowelable paste insulation for application over insulating cement or unfinished block insulation.

E. Finished Spaces: All areas except pipe and duct tunnels, shafts and chases, and spaces above furred or dropped ceilings.

F. Foamed Plastic: Plastic expanded by thermal or chemical means, containing closed cells throughout.

G. Glass Fiber: A composite material consisting of glass fibers with a resin binder.

H. Mineral Wool: A generic term which applies to all types of inorganic fibrous insulations.

I. Perm: The measure of vapor transmission in grains of water through one square foot of a membrane in an hour at one inch mercury pressure difference.

J. PVC (Polyvinyl Chloride): A polymerized vinyl compound using chloride.

K. Rock Wool: A generic term which applies to all types of inorganic fibrous insulations. Also includes mineral wool products.

L. Sealer: A liquid coating used to prevent excessive absorption of finish coats

into porous surfaces.

M. Solvent Weld: A bonding method which uses a liquid solvent to dissolve one substance or material to form an adhesive base to permanently seal a joint; usually associated with PVC plastic materials.

N. Vapor Retarder (formerly Vapor Barrier): A membrane installed on the high vapor pressure side of an insulation material to prevent moisture penetration. A vapor retarder shall have a rating of 0.02 Perms or less.

O. Vapor Retarder Jacket: Any material or composite meeting the requirements of a vapor retarder and used for the finish of insulation material. It may be factory furnished or field applied.

1.05 ACCEPTABLE MANUFACTURERS shall be the following, referred to hereafter by abbreviation.

A. Insulation - Glass Fiber Blanket, Molded Pipe, and Board Type:

1. Certain-Teed Corporation, Insulation Group - (C/T)
2. Knauf Fiberglass - (KF)
3. Manville Product - (MP)
4. Owens/Corning - (O/C)

B. Insulation - Foamed Plastic Types:

1. Armacell
2. Rubatex

C. Insulation - Polyisocyanurate:

1. O/C

D. Insulation - Calcium Silicate:

1. MP
2. O/C
3. Pabco Insulation Division
4. Calsilite Insulation Products

E. Insulation - Cellular Glass Types:

1. Pittsburg Corning - (PC)

F. Vapor Barrier Jackets - Factory Applied:

1. C/T
2. KF
3. MP
4. O/C
5. PC

G. Metal Jackets - Aluminum and Stainless Steel:

1. Childers Products Co.

2. Pabco Insulation Division
3. RPR Products, Inc.

H. Mastics, Adhesives, Sealants, Coatings:

1. AWI
2. Foster Products
3. KF
4. C/T
5. MP
6. O/C
7. PC
8. Rubatex
9. Childers Products
10. VIMASCO
11. Mon-Eco

I. Insulated Fitting Covers and Jacketing - PVC Types:

1. C/T
2. KF
3. MP
4. Foster Products

J. Outdoor Jacket – Roof Membrane

1. Sarnafil

K. Fire Rated Duct Wrap

1. 3M
2. Firemaster

L. Substitutions: Under provisions of Section 23 00 10 - Mechanical General Provisions.

1.06 QUALITY ASSURANCE: The installing Contractor for the insulation systems specified in this section shall have been in continuous, uninterrupted stable business for a minimum of five (5) years in the installation of industrial and heavy commercial insulating systems.

1.07 QUALITY CONTROL:

A. All insulation shall be installed in a workmanlike manner by skilled workmen regularly engaged in this type of work.

B. Insulation shall be applied on clean, dry surfaces and only after tests and approvals required by the Specifications have been completed.

C. Insulation jackets shall be drawn tight, fitted smoothly, and wrinkle-free.

D. Do not use short pieces of insulation where a full length section will fit. Do not use damaged or crushed insulation products.

E. Do not insulate manholes, handholes, cleanouts, inspection stamps, and nameplates. Bevel, flash, and seal around insulation of adjacent surfaces. On

equipment operating at temperatures below dew point of the space, provide removable insulation covers for such items and clearly mark the surface of the insulation cover to identify the hidden appurtenance (nameplate, inspection stamp, and the like).

F. Insulation on all cold surfaces shall be applied with a continuous unbroken vapor retarder seal. Hangers, supports, anchors and the like that are secured directly to cold surfaces shall be insulated and vapor retarder sealed to prevent condensation. Continue insulation with vapor retarder through penetrations of walls, floors, and the like.

1.08 FIRE HAZARD RATINGS FOR INSULATION, fasteners, mastics, adhesives, and jacketing materials shall not exceed flame spread of 25, fuel contribution of 50 and when used indoors, smoke development of 50 as determined by ASTM E-84, E-87, NFPA 255, and UL 723 tunnel test ratings. Flameproofing and fireproofing treatments are not acceptable.

1.09 ASBESTOS of any type shall not be allowed in any materials used under this Section.

1.10 PROTECTION SADDLES for use at pipe hangers and supports shall be as specified in Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

1.11 SUBMITTALS are required on all insulation, as hereinafter specified, to include manufacturer's material data, thickness for each service, standards compliance and installation procedures. Each item shall be a standard catalog product of an established manufacturer and of equal quality, finish, performance, and durability to that specified. Submittals shall include project specification and the specific technical paragraph reference which specifies each item and other information necessary to establish contract compliance of each item to be furnished. Deviations from the specifications and performance data shall be clearly itemized on the Shop Drawing cover sheet with technical paragraph reference of all non-complying items or features. Partial or otherwise incomplete submittals will not be acceptable and will be returned without review. Refer to Section 23 00 10 for additional requirements.

1.12 MOCK-UP: Samples of insulation and insulation finish systems shall be submitted prior to start of any insulation work on this project. The mock-up samples shall demonstrate compliance with the Contract Documents, establish installation and workmanship standards, and provide a quality control benchmark for comparing installed systems with the mock-up samples. Each mock-up sample shall be clearly tagged to indicate pipe service/insulation system/jacket system for which it is being submitted. Insulation thickness applied to the mock-up sample shall be as specified in Section 23 20 12 - Piping Schedule. Mock-up samples may be prepared on site for review and approval, subject to Engineer’s agreement, and shall be furnished as follows:

A. Valve Insulation System Mock-Up Requirements: Submit one (1) valve insulation assembly mock-up sample for approval for each cold (chilled water, city water, etc.) piping insulation system scheduled. Mock-up samples shall show fabrication techniques for jacket closure systems around valve bodies, stems, actuators, and the like. Submittals shall include one sample of each typical cold service valve type that will be installed on the project. Construct valve assemblies with a minimum of six inches of insulated pipe extending from each side of the valve. Provide at least the following samples for approval:

1. Chilled Water - 4" butterfly valve assembly

2. City Water - 2" ball valve assembly

B. Insulation Insert Mock-Up Requirements: Submit one (1) insulation insert/shield assembly mock-up sample for approval for each cold (chilled water, city water, etc.) piping insulation system scheduled. Refer to Section 23 05 29 and details on the Drawings for requirements. Submittals shall include one sample for each typical cold service insert assembly that will be installed on the project. Mock-up samples shall show fabrication techniques for insulation system sealing and joining with insulation inserts, as well as jacket assembly at the insert. Construct insert assemblies with a minimum of six inches of insulated pipe extending from each side of the insert. Provide at least the following samples for approval:

1. Chilled Water - 4" hanger support
2. City Water - 2" hanger support
3. Steam – 3” hanger support

C. The insulation subcontractor shall coordinate with the Mechanical Contractor as required for pipe sections, valves, and accessories needed to construct the mock-up insulation samples.

D. Outdoor Insulation Mock-Up Requirements: Submit one (1) insulation mock-up sample for approval for ductwork to be installed outdoors. Submittals shall include one sample a representative sample including ductwork, insulation, jacket, supports, and fasteners that will be installed on the project. Construct mock-up with a minimum twenty four inches of duct length with support for approval.

1.13 ALTERNATE INSULATION MATERIALS: Substitutions for alternate insulation products, materials or assemblies shall be submitted as required in Section 23 00 10 - Mechanical General Provisions. Substitutions of alternative materials to improve quality, construction schedule or costs will be reviewed by the Owner's representative, provided the documentation required in Section 23 00 10 is furnished. In addition, submit a mock-up sample(s) of the assembled proposed insulation system(s). Submit cost change proposed for the alternate insulation materials for consideration by the Owner.

1.14 WHEN UNABLE TO PROVIDE LABELING as required, submit certificates from the manufacturer stating that materials meet specified requirements.

1.15 DELIVERY, STORAGE, HANDLING, AND PROTECTION: Comply with Section 23 00 10, Mechanical General Provisions.

1.16 WARRANTY: Comply with Section 23 00 10, Mechanical General Provisions.

PART 2 - PRODUCTS

2.01 MOLDED GLASS FIBER INSULATION: Pipes and Circular Ducts: ASTM C-547 preformed glass fiber insulation. Insulation shall be Class 1 or 2, rigid, non-combustible, one-piece pipe insulation with 850°F maximum service temperature, nominal "K" value of 0.23 at 75°F mean temperature, jacket permeance of 0.02 perms for ASJ facing. When specified for applications requiring a vapor retarder seal, furnish insulation with ASJ and self-sealing lap (SSL) joint on longitudinal seams.

Acceptable Products:

A. C/T CertaBlue Bond SSL or ASJ, as specified.
B. KF Pipe Insulation ASJ-SSL or ASJ, as specified.
C. MP Micro-Lok AP-T Plus or AP, as specified.
D. O/C Fiberglas Heavy Density Pipe Insulation ASJ/SSL-II or ASJ, as specified.

2.02 FOAMED PLASTIC INSULATION: Pipe, Ductwork, and Equipment: ASTM C-534 closed cell elastomeric thermal insulation. Insulation shall be Type I (tubular) or Type II (sheet), water vapor permeability of maximum 0.20 perm-in per ASTM E-96, "K" value of 0.28 at 75°F mean temperature, service temperature range of -40 to +220°F. Pipe insulation to 1" thickness and 2" sheet shall have a maximum flame spread rating of 25, smoke developed 50 per ASTM E-84.

Acceptable Products:

A. Armacell AP Armaflex Pipe/Sheet Insulation
B. Rubatex Pipe Insulation/Sheet Insulation

2.03 FLEXIBLE GLASS FIBER INSULATION: Ductwork, Equipment and Pipe Accessories: ASTM C-553 glass fiber blanket insulation (industrial type). Insulation shall be Type I/Class B-4, resilient, flexible blanket insulation with minimum density of 1.50 lb/cu.ft., 250°F insulation service temperature, "K" value 0.25 at 75°F mean temperature (at labeled thickness), and permeance of 0.02 perms for the FSK (aluminum foil-fiberglass scrim-laminated kraft) facing.

Acceptable Products:

A. C/T Duct Wrap
B. KF Duct Wrap
C. MP Microlite Duct Wrap
D. O/C All Service Duct Wrap

2.04 RIGID GLASS FIBER BOARD INSULATION: Ductwork and Equipment: ASTM C-612 glass fiber board insulation (industrial type). Insulation shall be Class 1, rigid, heavy density board insulation with minimum density of 3.0 lb/cu. ft., 450°F insulation service temperature, "K" value 0.23 at 75°F mean temperature, and permeance of 0.02 perms for the FSK facing.

Acceptable Products:

A. C/T Industrial Insulation Board (IB 600)
B. KF Insulation Board (6.0)
C. MP 800 Series Spin-Glas (#817)
D. O/C 700 Series Insulation (#705)

2.05 VAPOR RETARDER (VAPOR BARRIER) JACKETS

A. Premolded PVC Fitting Covers, Pipe Covers, and Accessories - Pipe:

1. PVC jackets and accessories shall be self-extinguishing type, flame spread 25, smoke developed 50 as tested per ASTM E-84. Products shall also comply with NFPA 90A and 90B.

2. PVC jackets and accessories shall have a service temperature range of 0 to 500°F (ambient temperature range of 0 to 150°F) and moisture transmission less than 0.05 perms.

3. PVC jackets and accessories shall be minimum 20 mil (0.020 inch) thick, suitable for use with solvent type welding adhesive. All jacketing materials shall have a smooth, high gloss (sanitary) finish, UV resistant. Color: White.

4. Adhesives, tapes, sealant, and solvent weld compounds shall be compatible with the jacketing materials and recommended for use by the manufacturer. Vapor retarder jackets applied to the insulation shall also be compatible with the PVC jacketing.

5. Furnish precut or field fabricated insulation inserts for all pipe fittings and accessories. Insulation inserts shall be constructed of insulation matching the service pipe insulation. Furnish PVC fitting covers for elbows, tees, flanges, and, when mechanical joints are scheduled, furnish fitting covers for mechanical joint (Victaulic) piping.

6. For piping and round ductwork applications, provide pre-curled jacket sections sized to yield a minimum one inch (1") overlap of the installed insulation assembly. Pre-curled jacketing shall be MP Zeston 2000 PVC Cut & Curled jacketing or approved equal.

7. Acceptable products, subject to compliance with this specification: MP Zeston 2000 PVC, Foster Speedline 25/50 Smoke-Safe, Accessible Products Company Type 800HD, or approved equal.

B. Kraft and Foil (ASJ) - Pipes and Equipment: Meet or exceed ASTM C-1136, NFPA 90A requirements, permanently flame retardant and U.L. listed. Outer ply - minimum 35 lb. white bleached embossed kraft. Inner ply - aluminum foil reinforced with fiberglass yarn 1/16" o.c. both directions. Ply bonding adhesive - flame extinguishing. Water vapor permeance 0.02 perms or less, -20 to +450°F service temperature. Plain joint laps for field applied adhesive or laps with pressure sensitive adhesive will be accepted. Acceptable products: MP type AP or AP-T Plus, O/C 25 ASJ, C/T ASJ, or KF ASJ or equal.

C. Foil-Scrim-Kraft (FSK) - Ductwork: Meet NFPA 90A requirements, permanently flame retardant and U.L. listed. Inner ply - minimum 40 lb. flame resistant paper. Outer ply - aluminum foil, ply bonding adhesive - flame extinguishing. Water vapor permeance 0.02 perms or less, 40 to 250°F service temperature. Acceptable products: MP type FSK, O/C FRK 25, C/T FSK, or KF FSK.

D. Saran Vapor Retarder Film – Meet or exceed NFPA 90A requirements, Water vapor permeance 0.03 perms or less, ASTM E84 flame spread and smoke developed rating of 25/50 or lower, minimum tensile strength of 20 lb/sq. in.

2.9 PROTECTIVE/FINISH JACKETS

A. Canvas - Pipes, Ducts and Equipment: (Field Applied) U.L. listed, plain-weave 100 percent cotton fabric with hard twisted yarns, impregnated with a dilute fire retardant lagging adhesive, minimum 8.0 oz/sq.yd. unless scheduled otherwise. Furnish a certificate of compliance letter from the manufacturer to verify that the products provided meet the specification.

B. Fiberglass - Pipes, Ducts and Equipment: (Field Applied) Industrial quality fiberglass fabric constructed of glass fiber materials with a density of 0.094 lbs/cu.in. and tensile strength of 500 lbs. at 70°F. Jacketing fabric shall have a minimum density of 14 oz/sq.yd. and be treated by the manufacturer to contain a water-activated adhesive for lagging applications. Fiberglass jackets shall be Glas-Tex fabric (Style 84215, Finish 9995) as manufactured by J.P. Stevens Company, or equal.

C. Metal - Aluminum - Pipes and Accessories: (Field Applied)

1. Metal jacketing shall be 0.016" thick aluminum or aluminum alloys conforming to ASTM B-209. Metal jacketing installed outdoors shall be furnished with a stucco embossed pattern and 3/16" deep circumferentially corrugated exterior surface. Metal jacketing installed indoors shall be smooth, non-corrugated type. All jacketing shall have an integrally bonded moisture barrier coating over the entire surface in contact with the insulation. The moisture barrier coating shall be composed of one layer of one mil thick polyethylene film with a protective layer of 40 pound kraft paper, or the equivalent, to prevent moisture and corrosives within the insulation from contacting the metal jacket and causing a galvanic or chemical corrosion.

2. Outdoor jacketing shall be equivalent to Corrolon Jacketing by Childers Products Company. Indoor jacketing shall be equivalent to Rolled Jacketing by Childers Products Company.

3. Fastening devices shall be Type T-304 stainless steel bands, 0.020" thick, 1/2" wide, equal to Fabstraps by Childers Products Company.

4. Metal fitting covers shall be 0.024" thick aluminum with a smooth or stucco embossed exterior finish, moisture barrier coating on interior surface, and interlocking weathertight joints. Secure metal fitting covers with all-aluminum fasteners, such as pop-rivets, as necessary to secure fitting covers in place. Pop-rivets with galvanized or carbon steel pins shall not be used. Fitting covers for 90 or 45 degree elbows shall be equal to ELL-JACS Elbow Insulation Covers by Childers Products Company.

5. Miscellaneous insulation covers for Flanges, Valves, Blind Flanges, Reducing Flanges, Concentric/Eccentric Reducers, and the like, shall be constructed of 0.020" aluminum. Tees shall be constructed of two matching halves of 0.024" aluminum. All aluminum components shall have an integral moisture barrier coating, and all such fittings shall be either factory fabricated units or skillfully crafted field fabricated insulation covers.

6. Seal all laps, seams, joints and raw edges of aluminum jackets installed on outdoor piping or where required for indoor piping jackets with caulking or sealant; Childers Chil-Byl CP-76, Foster 95-44, or clear silicone caulking (G.E. 1200, or equal).

D. Premolded PVC Fitting Covers, Pipe Covers, and Accessories - Pipe and Ductwork: (Refer to previous paragraph, Vapor Retarder Jackets.)

2.10 ADHESIVES (FIRE RESISTIVE)

A. Canvas Jackets: For securing field applied canvas jackets on insulation, with or without vapor retarder, lagging adhesive shall have a dry flame spread rating of 5 per ASTM E-162, 0 to 180°F service temperature, water vapor permeance of 1.3 perms, white color, tough, washable finish when dry; Childers Chil-Seal CP-50A Coating, Foster Sealfas 30-36, Mon-Eco 11-02, or Vimasco 713.

B. Flexible Glass Fiber Insulation: For securing field applied flexible glass fiber insulation to ductwork, pipes & equipment (other than internal duct liner insulation materials), adhesive shall have a dry flame spread rating of 5 per ASTM E-162, -20 to 180°F service temperature, fast drying synthetic elastomer adhesive designed to adhere fibrous glass insulation to sheet metal; Childers Chil-Stix Clear CP-85, Foster Stic-Safe 85-15, or Mon-Eco 22-05.

C. Foamed Plastic Insulation: For securing field applied foamed plastic insulation to ductwork, pipes and equipment, adhesive shall have a dried film flame spread rating not to exceed 25 per ASTM E-84 and smoke developed rating of 50, service temperature to 200°F for pipe and sheet applications, contact adhesive for joining seams, butt joints, and surface adhesion; Armstrong 520 Adhesive, Rubatex R-373 Adhesive, or equal.

2.11 SEALANTS AND ACCESSORIES

A. Sealants - Vapor Retarder Finish: For all interior field constructed vapor retarder finishes for equipment, fittings, valves, flanges, surface patches, joints, staple punctures, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, 20 to 180°F service temperature, water vapor permeance to 0.02 perms, white finish color, flexible, high build product suitable for use as a vapor retarder finish on pipe and block insulation and rigid thermal insulation. Vapor retarder finish coating shall be Foster Vapor Safe 30-80, or approved equal by Childers or Mon-Eco.

B. Sealants - Weather Barrier Finish: For all exterior field constructed weather barrier finishes for equipment, tanks, fittings, valves, flanges, surface patches, joints, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, -20 to +200°F service temperature, water vapor permeance to 1.0 perm (aged value), white finish color, tough, durable, thixotropic trowelable product for use as mechanical protection and weatherproofing of outdoor thermal insulations. Weather barrier finish coating shall be Childers Vi-Cryl CP-10/11, Foster Sealfas GPM 35-00, Mon-Eco 55-50, or Vimasco WC-1.

C. Sealants - Foamed Plastic Insulations: For all exterior applications and indoor applications where specifically called for to provide a protective or vapor retarder coating on equipment, tanks, piping, fittings, valves, flanges, ductwork, joints, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, white finish color, resistant to ultra-violet effects, compatible with insulation and adhesives, tough, durable, weather-resistant finish. Sealants for foamed plastic insulation shall be Armstrong WB, Childers Vi-Cryl CP-10/11, or approved equal by Foster or Mon-Eco.

D. Sealants - Cellular Glass Insulations: For all applications where a vapor barrier joint sealant is specified on equipment, tanks, piping, fittings, valves, flanges, ductwork, joints, lap edges and the like: Moisture and vapor barrier joint sealant and bedding compound for rigid insulation, service temperature of -20 to 200°F, maximum 0.01 perm-inch water vapor transmission; Foster 30-46,

PC Pittcote 300, or insulation manufacturer's recommended sealant.

E. Reinforcing Mesh for Sealants: For all sealants specified or recommended by the manufacturer to be applied with a reinforcing mesh: High strength, open-weave pre-sized and resin treated fiberglass cloth, minimum 6x6 mesh (6 strands by 6 strands per square inch) conforming to ASTM D-1688 Type III, non-combustible, flexible, not subject to rot, mildew, or decay; Childers Chil-Glas #5 (or #10) or equal. Vimasco Elastafab 894 constructed of modacrylic fibers, or equal, is also acceptable.

F. Cements for Pipe and Equipment: ASTM C-449 blended mineral fibers and inorganic refractory materials, hydraulic setting binder, thermal insulating and finishing cement for applications to 1200°F. Product shall be trowelable over surfaces, valves, flanges, and irregular surfaces and be non-cracking and exhibit low-shrinkage. High temperature insulating cement shall be Pabco Pabcote One Coat Insulating Cement, Fibrex Superkote Cement, or equal by Power House.

G. Sealants - Miscellaneous Joints: ASTM C-920, Type S, NS, Class 25 construction sealant shall be non-toxic, weatherproof silicone sealant suitable for use in sealing construction joints, metal jacketing joints and seams, pipe hanger saddles, and the like. Sealant shall be General Electric Construction 1200 Series Silicon Sealant or approved equal. Color shall be translucent (clear) or white, as required to match adjacent material finishes.

H. Acoustical Sealants: Acoustical sealants for sealing around duct or piping penetrations of building construction materials shall be resilient, non-shrinking, non-hardening, non-drying, non-sag type sealant designed for interior use in sealing concealed construction joints. Apply acoustical sealant over a flexible, durable, non-absorptive, compressible rod stock (backer rod) of polyethylene foam, neoprene foam, or approved equal. Acoustical sealants shall be as manufactured by Tremco, U.S. Gypsum Co., Woodmont Products, or approved equal.

2.12 TAPE

A. Ductwork Insulation: For sealing FSK vapor retarder jackets on ductwork insulation, use 4” wide glass fabric tape imbedded in Foster 30-80 vapor barrier, fire resistant adhesive Do not use pressure sensitive tape.

B. Piping Insulation: For sealing ASJ vapor retarder jackets on piping insulation, use matching tape with a foil inner layer with acrylic adhesive, fiberglass scrim reinforcement imbedded between an outer layer of bleached white fire retardant kraft paper and the inner foil layer. Tape shall be nominal 3" width for pipe insulation applications up to 7-1/2" OD and nominal 4" width for pipe insulation over 7-1/2" OD, permanently flame retardant and U.L. rated, permeance rating of 0.02 perms, mold and mildew resistant.

C. Insulating Tape: For insulating short lengths of piping and fittings in congested or hard to reach areas, use an elastomeric insulation tape equal to Armaflex Insulation Tape, Rubatex R-180-FS Insulation Tape, or Halstead Insulation Tape. Tape shall be nominal 2" wide, self-stick adhesive backing, 1/8" thick, and suitable for use on pipe surfaces to 160°F. Use only in applications specifically approved by the Owner's representative.

2.13 OUTDOOR JACKET – ROOF MEMBRANE

A. Roof Membrane: For waterproofing ductwork outdoors, use thermoplastic PVC polymer membrane with integral polyester scrim reinforcement, off white exterior, heat weldable, Sarnafil S327 roof membrane. Membrane shall be o.045 inches minimum thickness, with 200 Lbf./in minimum breaking strength, 0.5% maximum linear dimensional change.

B. Roof Membrane Adhesive: For adhering membrane to clean and dry surfaces. Sarnacol 2121 water-based adhesive.

2.14 FIRE RATED DUCT WRAP: Ductwork: One layer wrap for grease ducts rated in accordance UL 1978 shall provide not less than the manufacturer's required thickness. Foil encapsulated mineral wool blanket shall provide a UL shaft enclosure rating of 2 hrs.

PART 3 – EXECUTION

3.1 INSPECT ALL SURFACES AND VERIFY that work of other trades requiring insulation has been completed and is ready to receive insulation. Specifically check for obvious defects such as leaking pipe or duct joints, broken fittings, hanger supports, and the like, that would result in damage to the completed insulation job, or that would adversely affect the execution and quality of the insulation systems as specified. Do not proceed with application of insulation until defects are corrected.

3.2 REMOVE ALL DIRT, SCALE, OIL, GREASE, or other extraneous loose material from surfaces to be insulated.

3.3 VERIFY that piping, ductwork, equipment, vessels and the like have been tested in accordance with the Specifications prior to applying insulation materials.

3.4 INSTALL SPECIFIED MATERIALS either as sequentially applied components or as a composite system if applicable. Follow manufacturer's installation guides and instructions.

3.5 PIPE AND EQUIPMENT INSULATION

A. Molded Glass Fiber Insulation: Apply thickness shown in insulation schedule.

1. Sectional and segmental jacketed pipe insulation shall be applied so that ends of adjacent sections are butted tightly against each other. Sections of pipe furnished with all service jacket shall be securely taped in place on all longitudinal seams and circumferential joints. Sections of pipe furnished with all service jacket with self-sealing lap shall have the integral lap seam secured and all circumferential joints securely taped. Tape shall match the pipe insulation jacket.

2. Sectional and segmental unfaced pipe insulation shall be applied so that ends of adjacent sections are butted tightly against each other. Sections shall be securely wired or banded in place using not less than three ties of wire or two bands every eight inches (8") on center for each 3 ft. section on pipe sizes up to and including 6" size. For larger pipes, use two bands every eight inches (8") on center per 3 ft. section.

Wires shall be drawn taut to embed them flush with the insulation, firmly twisted, excess clipped and ends bent over and fully embedded into the insulation prior to application of finish jacketing.

3. Flanges, Strainers, Automatic and Manual Valves and Bonnets: Cover with plain duct wrap of 1.5 lb/cu. ft. minimum density, wrapped firmly under compression, and wired in place. Finish with 1/4 inch layer of hydraulic insulating cement to a thickness equal to adjoining insulation.

4. Fastening: Secure insulation jacket with lagging adhesive (Childers CP-50A or Foster 30-36) if not provided with self-sealing pressure-sensitive adhesive. In areas not accessible after construction, also secure insulation with aluminum bands on 12 to 18 inch centers.

5. Cover fittings (standard or Victaulic type) with one piece PVC premolded fitting covers stapled or tacked in place. Apply over proper shape factory precut insulation blanket. Before applying fitting cover on piping requiring a vapor barrier, apply two vapor barrier mastic beads 1/8" in diameter around pipe covering close to end of covering before applying PVC cover. Wrap circumferential edges of cover with vapor-barrier pressure sensitive color matching tape. Overlap tape 2 inches on adjacent insulation and on cover.

B. Foamed Plastic Insulation: Apply thickness shown in insulation schedule.

1. Piping Applications:

a. Unslit tubular insulation shall be slipped onto piping before it is connected.

b. Preslit tubular insulation shall be rolled onto piping after fabrication.

c. Tightly butt adjacent sections and seal with a contact adhesive specifically approved by the insulation manufacturer (Armstrong 520, Rubatex R-373, or equal). Fabricate fitting covers from miter cut tubular insulation using over-sized insulation segments lapped over adjacent sections. Do not stretch insulation to fit; use proper lengths of materials.

d. Unless scheduled otherwise, indoor applications will not require protective finish coats. Provide high density insulation inserts (calcium silicate or compressed glass) at the hanger support and the pipe to prevent compressing the foamed plastic insulation at pipe hangers. Thoroughly seal all joints at the insulation inserts. When protective or weather barrier finishes are specified, apply a single layer of reinforcing fiberglass cloth fully adhered to the surface. Apply two finish coats of sealant specified for foamed plastic insulations. Adhesives and sealants shall be compatible and approved for use on foamed plastics.

2. Ductwork and Equipment Applications:

a. Tightly butt adjacent sections and seal with a contact adhesive specifically approved by the insulation manufacturer (Armstrong

520, Rubatex R-373, or equal). Make all cuts square and apply with smooth skin surface facing out. Do not stretch sheets to fit; cut a new piece for proper fit.

b. Unless scheduled otherwise, indoor applications will not require protective finish coats. When protective or weather barrier finishes are specified and for all outdoor installations of foamed plastic insulations, apply a single layer of reinforcing fiberglass cloth fully adhered to the surface. Apply two coats of sealant specified for foamed plastic insulations. Adhesives and sealants shall be compatible and approved for use on foamed plastics.

C. Calcium Silicate Insulation: Apply thickness shown in insulation schedule.

1. Tightly butt edges, half-sections and break joints. Secure with wire for small areas, and aluminum bands 12" o.c. for large areas. Where required, provide welded studs, clips or angles as anchors for wires and bands.

2. Cover valves, bonnets, flanges, and fittings with molded calcium silicate fitting insulation where commercially available.

3. Cover valves, bonnets, flanges, and fittings with fabricated, mitered segments of molded calcium silicate of same thickness as insulation on adjacent pipe, wired in place. Finish with 1/4" thickness of hydraulic insulating and finishing cement.

4. Fittings on pipe sized 1-1/2" and smaller may be insulated with hydraulic insulating and finishing cement of same thickness as pipe insulation.

5. Cover equipment with fabricated, mitered segments of molded calcium silicate of same thickness as insulation on adjacent pipe, wired in place. Finish with 1/2" thickness of hydraulic insulating and finishing cement, with metal corner beads.

6. Cover equipment removable heads with 20 gage galvanized steel cover over insulation.

7. Where no additional finish is specified, apply 16 gage nickel copper alloy wire, 16 gage copper clad steel wire, or 16 gage stainless steel wire on 4" centers up to 6" pipe and 6" centers on pipe over 6" diameter.

8. Block insulation greater than 2" thick shall be applied in layers not exceeding 1-1/2" thick. All joints shall be staggered. Secure with wire. Cover with 1/2" thick hydraulic insulating and finishing cement. Protect all corners with metal corner beads.

D. Polyisocyanurate Insulation: Apply thickness and density shown in insulation schedule.

1. Apply single layer, half-sections of insulation to pipe and fittings. Provide fabricated coverings suitable for use on valves, pipe fittings, and steam and hydronic specialties, for proper fit. Tightly butt edges and seal all joints full depth with manufacturer's sealant. Do not use sealant

to fill voids or cracks. Check for tight seal at all joints and edges and reapply sealant as necessary. Do not use broken or cracked insulation products.

2. Secure insulation to piping with factory applied Saran jacket with self sealing lap in accordance with the manufacturer's recommendations. Provide a minimum two inch overlap of jacket at all joints, both circumferential and longitudinal. Jacket shall be thoroughly sealed to form a vapor retarder seal over the entire insulation assembly.

3. Cover Saran jacket with canvas to secure and protect. Fittings shall be covered with approved PVC jacketing over the specified insulation and shall be completely vapor retarder sealed.

4. Verify that all sealants, mastics, and the like are compatible for use on the specified insulation systems. Allow adequate curing time for all sealants and mastics prior to covering with insulation finish systems.

5. Inspect all insulation and accessory materials to be certain that the installation is in conformance with the manufacturer's recommendations and the requirements of referenced ASTM standards and this Specification Section. All joints shall be tight with complete sealing for vapor retarder. Exterior finish shall be uniform, free of defects, and installed in a neat workmanlike manner.

E.

3.6 DUCTWORK AND EQUIPMENT INSULATION

A. Rigid Glass Fiber Board: Apply thickness shown in ductwork schedule.

1. Cut insulation to fit between standing seams and stiffeners. Secure to metal with welded pins and self-locking caps installed flush with adjacent insulation surface. Pins shall be spotted 18" o.c. with not less than two rows of pins per side and with one pin spaced 3 inches in from each corner. Apply a heavy bead of vapor barrier sealant around each weld pin before installing cap. Caps shall match color of glass cloth jacket if used.

2. Cover fittings with material of same type and thickness. Score as necessary for curved surfaces.

3. Vapor retarders for FSK faced insulation shall overlap a minimum of 2" at all seams and be sealed with woven glass fabric tape with mastic. All penetrations, facing damage, and mechanical fasteners shall be covered with a minimum 2" overlap of tape or mastic.

4. Where scheduled, cover with finish jacketing of PVC or canvas.

3.7 CEMENTS, INSULATING AND FINISHING: Unless specified to the contrary elsewhere, provide a finished thickness of 1/2". Apply in two layers, reinforcing with No. 16 AWG 1" mesh galvanized wire netting. Trowel to a smooth hard finish. Install metal corner beads at all corners.

3.8 FIRE RETARDANT VAPOR RETARDER JACKETS FOR PIPE AND EQUIPMENT (ASJ)

A. Apply adhesive and jacket over insulation. Seal lap with field applied adhesive or factory applied pressure sensitive lap adhesive.

B. Apply sealant to fittings, valves, flanges and similar items. Vapor seal these items by embedding reinforcing mesh (fiber glass fabric) between two 1/16" thick coats of adhesive. Lap seal fabric 1 to 2 inches on itself and 2 inches on adjoining insulation.

C. Apply flashing on pipe, ductwork and equipment for a complete moisture and vapor seal at all metal-to-insulation joints, exposed edges of insulation and other protrusions through jackets, including staples and other fasteners. Apply a continuous bead or fillet of flashing sealant to completely seal the joint. Extend a 1/16" film of flashing sealant over adjacent insulation and metal surfaces at least 3". Embed glass fabric into the wet coating over entire surface, smoothing out all wrinkles. Immediately apply a 1/8" film of flashing sealant to the entire membrane surface leaving a large bead or fillet over the joint. All sealant shall dry, then extend adjacent finish over the flashing a minimum of 3 inches.

3.9 FIRE RETARDANT VAPOR RETARDER JACKETS FOR DUCTWORK, EQUIPMENT AND PIPE (FSK)

A. Apply Foil-Scrim-Kraft with adhesive over glass fiber insulation unless Foil-Scrim-Kraft is furnished integrally with the flexible or rigid insulation. Apply fire resistive adhesive sealant to full surface of laps and secure them with staples applied 6" o.c. Vapor seal all lap edges, jacket breaks, penetrations and staples with woven glass fabric tape with integral or field applied full coverage coating of fire resistive adhesive. Lap tape not less than 1 inch on itself and adjacent insulation. Finish shall be wrinkle-free. Cover breaks and penetrations with 3 inch width strip of glass fabric embedded between two 1/16" coats of vapor retarder sealant, lapping fabric not less than one inch on adjacent insulation.

B. Apply flashing on pipe, ductwork and equipment for a complete moisture and vapor seal at all metal-to-insulation joints, exposed edges of insulation and other protrusions through jackets, including staples and other fasteners. Apply a continuous bead or fillet of flashing sealant to completely seal the joint. Extend a 1/16" film of flashing sealant over adjacent insulation and metal surfaces at least 3". Embed glass fabric into the wet coating over entire surface, smoothing out all wrinkles. Immediately apply a 1/8" film of flashing sealant to the entire membrane surface leaving a large bead or fillet over the joint. All sealant shall dry, then extend adjacent finish over the flashing a minimum of 3 inches.

3.10 CANVAS JACKET: Cover entire insulation surface with canvas embedded between two 1/8" thick layers of lagging adhesive. Where canvas jacket is specified on cold surfaces and otherwise scheduled, embed canvas between two 1/8” thick layers of high build vapor retarder sealant. Overlap canvas at least 2" on itself and adjoining surfaces. Provide premolded PVC fitting covers for all insulated fittings, valves, and the like installed on systems scheduled to receive canvas jackets. PVC fitting covers shall be as specified elsewhere in this section.

3.11 FIBERGLASS JACKET: Cover entire insulation surface with fiberglass jacket between two 1/8" thick layers of lagging adhesive, liberally applied. Overlap fiberglass jacket at

least 2" on itself and adjoining surfaces. When applied on chilled water pipe insulation systems, provide a continuous vapor seal and smooth exterior finish. PVC fitting covers shall be as specified elsewhere in this section.

3.12 METAL JACKET: Cover entire insulation surface of piping with aluminum jacket and fitting covers. Locate longitudinal joints along the side of horizontal piping, with a minimum 1" wide overlapped joint positioned to shed water. Overlap circumferential joints 2" minimum. Seal all longitudinal joints and circumferential joints with vapor barrier sealant. Secure jacket in place with stainless steel bands on 10" maximum center-to-center spacing. Use a minimum of 3 stainless steel bands on each fitting cover. Pop rivets and/or screws shall not be used on metal jacketing.

3.13 PVC JACKET: Cover entire insulation system in designated areas with a 20 mil thick PVC jacket. Jacketing system shall be continuous to cover all straight lengths of pipe and fittings, flanges, valves and pipe terminations, and ductwork systems when scheduled for PVC jacket. All lap joints (longitudinal and circumferential) in the jacketing system shall be permanently sealed with a solvent weld type adhesive equal to M/P Zeston PermaWeld. All pipe fittings shall be insulated by applying the proper size and type of precut insulation insert to the pipe fitting prior to installing the PVC fitting cover. Install PVC fitting cover in accordance with manufacturer's recommendations to ensure good adhesion. Apply the PVC jacketing over the pipe insulation and overlap the fitting cover by approximately one inch and apply the manufacturer's solvent adhesive to all circumferential and longitudinal joints and overlaps. Inspect all seams and overlaps and touch-up with adhesive as required. Domestic and chilled water piping and ductwork systems shall have a vapor retarder jacket applied prior to installing the PVC jacket, unless scheduled otherwise. High temperature systems shall be installed with appropriately spaced slip-joints in the PVC jacket as per the manufacturer's recommendations.

3.14 INSULATION SCHEDULE (See Also Drawings)

A. General: Specific details and notes in this schedule shall take precedence over other paragraphs of this Specification Section 23 07 00. For example, if the product specification in Part 2 above calls for 1.5 pounds per cubic foot minimum density, and this schedule calls for 3.0 pounds per cubic foot (PCF), then the scheduled 3.0 PCF applies to this job.

B. Ductwork: Duct insulation shall be as scheduled in Section 23 31 15 - Ductwork Schedule - Service and Material Systems.

END OF SECTION

SECTION 23 09 00
INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 SCOPE OF WORK - OVERVIEW:

A. It is intended that the Facility Management System (FMS) Control and Instrumentation work shall be a subcontract to the Mechanical Contractor. Where the Specification refers to the Controls Contractor, it shall be understood that the Controls Contractor is a subcontractor to the Mechanical Contractor.

B. Furnish and install a complete electronic Building Automation System for the HVAC system, including all control accessories, hardware, software, and devices necessary to execute the sequence of operation.

C. All control wiring, devices, and components shall be new. No existing valves, sensors, actuators, transmitters, or components may be reused.

D. These Specifications, together with the information shown on the Drawings, define the automatic control of all equipment described under "Sequence of Operation". The automatic temperature control system includes, but is not limited to, temperature transmitters, controllers, automatic dampers and valves, damper operators, switches, control panels and other accessory equipment and devices along with a complete system of control, pneumatic tubing, and electrical wiring to fulfill the intent of these Specifications and to provide for a complete and operable system.

E. The system shall be installed, started-up, and serviced by factory trained mechanics and system specialists regularly employed by the manufacturer of the control equipment.

F. The system vendor shall have an operating branch office within 100 miles of the job site, and shall show proof of this branch office providing engineering, installation, start-up, on-going support and services for the proposed type system for the past 10 years.

G. Contractors shall note that the requirements of this section are specific and describe in detail the exact components and system capabilities necessary for the optimum operation of the facility's HVAC equipment. All requirements will be strictly interpreted and enforced by the Engineer and his representative. Failure to comply with any provision may result in rejection of submittals and/or default.

H. The Mechanical Contractor shall include in his bid all work required by the Mechanical Contractor in this section, such as the installation of control valves and dampers, sensors and the like.

I. The above overview is general and is not all-inclusive. Refer to the

Specifications and Drawings for the complete work required.

1.03 GENERAL:

A. Include all labor, materials and appliances required for furnishing, installing testing, adjusting and placing in operation all control and instrumentation work shown on the Drawings and specified herein, complete and satisfactory to the Owner's representative.

B. The Controls Contractor shall furnish and install all equipment, accessories, electrical control and interlock wiring and instrument piping required for complete and functioning control system except as described under "Work by Others" in Part 3 of this Section.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems, and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use. No used or existing control equipment will be permitted in the new control system.

D. The DDC (Direct Digital Control) System shall be of a fully modular architecture, permitting expansion by adding computer memory, application software, operator peripherals and field hardware.

E. Tie-ins are required into Mechanical Contractor furnished equipment. The Controls Contractor shall coordinate.

F. The Controls Contractor shall provide a permanently assigned engineering and construction coordinator that is experienced in coordination and directing work of the magnitude and complexity of this project. The Controls Contractor shall submit for review and acceptance by the Engineer prior to commencing the work, the name of the proposed coordinator to be assigned to this project. This coordinator shall be assigned to this project until final site visitation unless otherwise released by the Engineer.

H. The Controls Contractor shall provide Local Area Network connection at each specified panel location so that future panels may be connected. Software shall provide for overall points to be added without any additional software cost to the Owner.

I. The Controls Contractor must provide the labor to design the graphics displays for all the new systems on all of the existing graphical workstations.

1.04 WORK BY OTHERS:

A. Automatic control valves and separable wells for immersion elements shall be furnished by the Controls Contractor and shall be installed by the Mechanical Contractor under this contractor's supervision. The Mechanical Contractor shall provide and install pressure taps, isolation valves and other couplings required by any pressure and/or flow instrumentation specified below.

B. Automatic (control and smoke) dampers shall be furnished and installed by the Mechanical Contractor under this Contractor's supervision. It shall be the responsibility of the Mechanical Contractor to see that the dampers are

correctly installed so that they operate freely and close tightly. It shall be the responsibility of the Mechanical Contractor to provide and install transitions when the control application requires dampers smaller than duct size. It shall be the responsibility of the Mechanical Contractor to provide and install round or oval to rectangular transitions when the control application requires dampers in oval or round duct.

C. The Mechanical Contractor shall install, in a neat and professional manner, all air flow measuring stations. He shall take great care to follow the manufacturer's instructions. Where transitions are required, he shall furnish 15 degree transitions so as to minimize the air disturbance. Access doors shall be furnished and installed by the Mechanical Contractor to allow access to the flow station sensing grid.

D. All finish painting required for building management and control equipment shall be done by the Mechanical Contractor.

E. All cutting and patching necessary for the installation of the Building Management and Control System shall be done by the Mechanical Contractor at the expense of this Contractor.

F. Refer to Section 23 00 10 for complete details of Mechanical, Electrical, and Controls work coordination.

1.05 REFERENCED STANDARDS, CODES, AND ORDINANCES:

A. It is the responsibility of the Controls Contractor to be familiar with all codes, rules, ordinances, and regulations of the authority having jurisdiction and their interpretations which are in effect at the site of the work.

B. The latest issue of applicable standards and recommended practices of the following agencies in effect shall form a part of the specification to the extent each agency's relative standards or recommended practices apply to the systems and their components as specified herein.

1. Federal Communications Commission (FCC)
2. American National Standards Institute (ANSI)
3. American Society of Mechanical Engineers (ASME)
4. Electronic Industries Association (EIA)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA)
8. Underwriters Laboratories (UL)
9. Occupational Safety and Health Administration (OSHA)
10. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

C. The Controls Contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and using industry accepted installation procedures required for the work as outlined in these documents.

D. All systems' equipment, components, accessories, and installation hardware shall be new and free from defects and shall be in accordance with the National

Electric Code and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All systems' components of a given type shall be the product of the same manufacturer.

E. The Controls manufacturer shall have ISO 9002 certification for all controls products used. Proof of such certification shall be supplied to the Engineer for approval prior to acceptance.

1.06 INTENT OF SPECIFICATIONS AND DRAWINGS:

A. It shall be understood that the Drawings and Specifications describe the approximate locations of the work. Do not scale the Drawings to determine exact positions and clearances. Obtain from the Engineer any dimensions not shown.

B. Bring to the attention of the Engineer, immediately, any changes in the size or location of the material or equipment which may be necessary in order to meet field conditions, or in order to avoid conflict with the equipment of other sections. Obtain the Engineer's approval before such deviations are made.

C. Details of construction and of workmanship, where not specifically described herein or indicated on the Drawings, shall be subject to the Engineer's approval.

D. Obtain from the Engineer at the site the location of any apparatus not definitely located on the Drawings. Locate equipment and accessories in such a manner as to provide easy access for proper service and maintenance. Special care is required to provide accessibility to openings in equipment requiring maintenance. Bring to the attention of the Engineer any condition which prevents adequate accessibility for maintenance, prior to installation of that work.

E. Before submitting proposals, examine the Specifications and Drawings relating to the work and become fully informed as to the extent and character of the work and the relation of the work to that of other sections. Examine the Drawings of other sections to become familiar with all the possible problems and details of the building construction which affect the work.

1.07 SHOP DRAWINGS:

A. Submittals shall comply completely with Section 23 00 10, Mechanical General Requirements.

B. Submit for review by the Owner's representative, prior to purchase or installation of equipment, shop drawings of all major equipment and all specially constructed equipment proposed for use in the project. Submittals shall consist of manufacturer's scale drawings, cuts or catalogs, including descriptive literature which shall indicate the construction, material, physical dimensions and complete operating data. All automatic controls shop drawings shall contain a verbal description of the sequence of operations, enumerating and describing the function of each component.

C. Provide complete catalog cuts, engineering data and other applicable information on all items of equipment. Submittals shall include product bulletins, engineering manuals, application manuals, installation manuals, and commissioning/troubleshooting manuals for all devices.

D. The following submittals are required:

1. System architecture showing all digital devices
2. Detailed points list indicating points to be graphically displayed, including adjustment, alarms, and trends
3. Detailed color conventions for all graphics and graphic elements
4. Valves, actuators, and accessories
5. Dampers, actuators, and accessories
6. Control and wiring diagrams of controlled mechanical systems
7. Control unit panels, point layouts, and addresses
8. Sarter and interlock wiring diagrams
9. Squences of operation
10. Material lists with part numbers, quantities and descriptions
11. Technical data sheets for each piece of equipment
12. As-built drawings with interconnecting wiring diagrams or wire lists of the complete field installed system with complete, properly identified ordering numbers of each system component and device.
13. Operator's manual(s) with pictures and step-by-step operating procedures. This manual shall be indexed and shall have a separate tabbed section for each operator function.
14. Trunk cable schematic showing remote unit locations and all trunk data conductors.

1.08 SYSTEM COMMISSIONING:

A. After equipment and control system start-up is complete, verify all graphics are complete and loaded prior to system commissioning and coordinate with Commissioning Agent.

B. Provide assistance during commissioning as required to complete the commissioning procedures.

1.09 SYSTEM ACCEPTANCE:

A. Submittal data relevant to point index, functions, sequences, interlocks, and associated parameters, and other pertinent information for the operating system and data base shall be forwarded from the Contractor to the Owner. Prior to full operation, a complete demonstration of the system operation shall be performed in the presence of the Owner and the Engineer. This demonstration, having satisfactorily met previously approved submittals, shall, with the Owner's written acceptance, allow commissioning of the system. Upon successful completion of system operation, the Owner and Engineer shall be requested, in writing, to inspect and approve the satisfactory operation of the system, sub-systems, and accessories. Upon completion of the installation, the System contractor shall start up the system and perform all necessary testing and debugging operations. An acceptance test in the presence of the Owner's representative, the Architect, and the Engineer shall be performed. When the system performance is deemed satisfactory in whole or in part by the

observers, the system parts will be accepted for beneficial use and placed under warranty.

B. Problems which occur within approved hardware or software shall be corrected in an appropriate fashion under warranty. Any such occurrence shall not void previous approval; however, the System Contractor shall be responsible to attend to and remedy such items within the warranty period. Appropriate logs, schedules and reports shall be maintained to reflect these items and their redress.

1.10 OWNER'S INSTRUCTION: The System Contractor shall provide four bound copies and an electronic copy of an operator's manual describing all operating and routine maintenance service procedures to be used with the system. The system contractor shall instruct the Owner's designated representatives in these procedures during the start-up and test period and commissioning phase. This instruction shall be conducted during normal working hours.

1.11 SHIPPING TAG: Each component shall be tagged at the factory with its specific location on the job, including AHU designation, building floor, room/area served, and the unit designation shown on the Drawing.

1.12 NAMEPLATES: Provide nameplate on each component as required by Section 23 05 53 - Mechanical Identification.

1.13 WARRANTY:

A. The control system herein specified shall be free from defects in material and workmanship under normal use and service for a period of twelve (12) months after final inspection and acceptance by the Owner, under the provisions of Section 23 00 10.

B. If within the twelve (12) month period, any equipment, software, or labor is found to be defective in workmanship or materials, it shall be replaced or corrected free of charge by the FMS Controls Contractor.

C. Factory authorized warranty service shall be required within 100 miles of jobsite, 24 hours per day, 7 days per week.

PART 2 - PRODUCTS

2.01 MANUFACTURER:

A. The control system shall be furnished and installed by Johnson Controls, Trane, or Alerton. Bids by suppliers other than those listed are not acceptable.

B. The Control Contractors listed above shall submit a "Line-by-Line" description to the Engineer detailing where their system does not meet the Specification. Failure to submit this description signifies that the product proposed will comply with the Specification in product and performance. If it is discovered that the installed system does not comply with the Specification in the period before the warranty period is complete, the system shall be removed and the specified system shall be installed. The cost for this new system and the cost for delays shall be by the vendor and his contractors.

2.02 SYSTEM AND CONTROL CONCEPT:

A. Overview:

1. Information is provided in this Specification Section for a complete distributed DDC system.

2. This Specification also defines the requirements for Direct Digital Control (DDC) systems that are equipped to interface with the Owner's monitoring and control system and both analog and binary inputs/outputs on a "stand-alone" basis. The objective of this control concept is to provide a control system with a maximum level of flexibility and reliability by distributing control requirements over a network of small microprocessor-based control modules. The system shall perform enhanced control operations to minimize energy consumption.

B. System Concept:

1. The Integration Platform shall include, but not be limited to, the following components/sub systems to provide a fully functional platform required for integrating building systems:
   a. Niagara Web Supervisor
   b. Niagara Workbench
   c. Associated Niagara drivers and applications
   d. Niagara based hardware platforms (JACE)
   e. Installation, engineering, programming. commissioning

2. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.

3. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS.

4. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any designated computer on the owner's LAN.

5. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.

6. The integration platform server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the Niagara 4 Framework server.

7. A laptop computer shall be provided by the owner for installation of engineering/programming software (Niagara 4 Workbench).

8. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the

following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". In any case, the end user shall maintain the right to instruct the contractor to modify any software license, regardless of supplier, as desired by the end user. The contractor shall not install any "brand-specific" software, applications or utilities on Niagara Framework-based devices. All hardware and field-level devices installed shall not be limited in their ability to communicate with a specific brand of Niagara Framework JACE. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed, in replacement of or in parallel with existing components. All controllers must be able to be programmed within the Niagara Workbench. At the completion of the project, the owner shall be given all existing platform and station login credentials to include; super user (admin) user names; passwords and passphrases.

9. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.

2.03 HARDWARE:

A. JAVA APPLICATION CONTROL ENGINE JACE-8000 and EDGE-10:

1. The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The JACE shall connect to the owner's local network, wide area network, or operational technology network (OTN) depending on configuration. Each JACE is capable of communicating to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.

2. The JACE shall be model JACE-8000 (JACE-8000) EDGE -10 (VEC-10) with corresponding IO and Communications modules.

B. Sensors and Field-Mounted Devices:

1. Temperature Sensors:

a. Temperature sensors shall use platinum elements where resistance increases with temperature in a known and repeatable manner.

b. All sensors of a particular category shall be of the same type and manufacturer. Provide temperature sensors suitable for one or more of the following mounting methods:

(1) Room Type - Suitable for wall mounting with mounting bracket, wallplate adapter, element holder and cover enclosure.

(2) Insertion Type - Suitable for insertion into air ducts at any angle with element holder and cover enclosure.

(3) Immersion Type - Suitable for immersion into fluids in tanks or pipes with separable immersion well, sealant, spacer, adapter, handi-box, and heat transfer compound.

(4) Averaging Type with Extended Element - Suitable for duct mounting to obtain average temperature by sampling along a capillary tube element not less than 10 ft. in length.

(5) Outside Air Sensing Type - Suitable for outdoor location with metal housing and located to minimize building outside air film effects.

c. Temperature sensor specifications shall comply with the following performance criteria:

Temperature Elements	Nickel RTD
Sensor Accuracy	$\pm$ 0.34°F @ 70°F
Reference Resistance	1000 ohms @ 32°F
Temperature Range	-50 to 275°F

2. Humidity Sensors: Thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degree F. Duct mounted type sensors shall have a stainless steel insertion element, sealed to prohibit corrosion. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

3. Carbon Dioxide Sensor:

a. The carbon dioxide sensor shall be wall mounted near return inlets and determine concentration of CO_2 by measuring the attenuation of a specific wavelength of infrared light as the light travels from its source to a detector along a defined optical path.

b. Device specifications shall comply with the following:

Measurement range	0 to 2000 ppm CO_2
Accuracy	+100 ppm CO_2
Repeatability	+20 ppm CO_2
Drift	+100 ppm CO_2 per year
Output signal	0 to 10 VDC proportional over the 0 to 2000 ppm CO_2 range
Accessories	Single-point calibration kit, filter

4. Line Voltage Thermostats:

a. Line voltage or control voltage thermostats for ventilation fans, unit heaters, and the like shall be Penn Model A19-B coiled bulb type, with single-pole double-throw contact mechanism 30° to 120° range, 16 amp rated, and adjustable deadband.

b. Line voltage thermostats shall be provided by the Controls Contractor as detailed on the individual control diagrams.

5. Differential Air Pressure Switch: Differential pressure switches for proving fan operation or sensing dirty air filters shall be SPDT type, UL approved, and selected for the appropriate operating range of the equipment to which it is applied. Sensor shall have 1/4" compression type fittings and shall have an adjustable setpoint. Furnish with 1/4" barbed type static pressure tips.

6. Differential Pressure Transmitters: For sensing the differential pressure in a distributed piping system, furnish a self-contained type differential pressure transmitter, 4 - 20mA output, accuracy of plus or minus 0.25 % of calibrated span, and -40 to +220 degree F operating temperature limits. Design range shall be as required for the system.

7. Current Switches: For proving fan or pump operational status, provide solid or split-core type current status switches with adjustable setpoint and solid state internal circuitry. Current switch shall have induced power, trip point set adjustment to plus or minus 1% over a range of 1 to 135 amps, trip and power LED, and field adjustable to indicate both On-Off conditions and loss of load (broken belt, etc.). Units shall have a five year warranty. Current switches shall be Hawkeye Series by Veris Industries, or approved equal.

8. Output Devices:

    a. Control Relays: Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.

    b. Reed Relays: Reed relays shall be encapsulated in a glass-type dust tight enclosure and plugged into a plastic or epoxy case. Contacts shall be rated for 150% of the loading applications. Operating and release time shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations and shall be equipped with coil transient suppression devices.

    c. Solid State Relays (SSR): Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20^{o}F - 140^{o}F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression shall be provided as in integral part of the relays.

9. Dampers:

    a. Control dampers for HVAC systems shall be provided to allow effective modulation or close-off of air flow as required for each

fan system. Damper frames shall be constructed to facilitate field assembly of several individual sections into larger damper area and shall be provided with openings or mounting clips to allow secure fastening of damper frame to the surrounding ductwork, collar, or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided with suitable bearings for smooth operation and all blades shall be interconnected to provide unison operation.

b. Dampers shall be provided with either parallel or opposed blade linkage and arranged for normally-open or normally-closed operation as shown on the drawings. Multi-section dampers shall be provided with sufficient interconnecting hardware and jackshafts to provide unison operation of all blades in the entire assembly.

c. Ultra Low Leakage Control Dampers:

(1) Frames shall be 5" x 1" x 0.125" 6063 T5 extruded aluminum channel. Dampers 12" high and less shall be equipped with low profile (5" x 1/2") frame dimensions.

(2) Blades shall be 6" wide 6063 T5 heavy gage extruded aluminum airfoil shape.

(3) Axles shall be 1/2" plated steel hex for positive connection with blades.

(4) Bearings shall be non-corrosive two-piece molded synthetic.

(5) Blade seals shall be extruded vinyl double edge design with inflatable pocket which enables air pressure from either direction to assist in blade to blade seal off. Blade seals shall be locked in extruded blade slots without the use of cement.

(6) Jamb seals shall be aluminum flexible metal compression type.

(7) Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

(8) Dampers shall be rated for temperatures from -50^{o}F to 250^{o}F.

(9) Leakage rate shall be tested and rated in accordance with the Air Movement and Controls Association (AMCA) Standard 500.

(10) Dampers shall be Model CD50 ultra low leakage airfoil control dampers as manufactured by Ruskin or approved equal.

d. Damper Actuators:

(1) Damper actuators shall be direct mounted, electric, solid-state drive by Belimo or equal. Torque ratings sized to meet system requirements as determined by the Controls Contractor.

(2) Control inputs shall be On-Off/Floating control or proportional control as required.

(3) VAV controllers shall have auto zero function.

(4) The actuator assembly shall include all necessary hardware and brackets to allow proper mounting and connection to damper shafts.

10. Combination Fire/Smoke Damper - Airfoil Blade:

a. Frames shall be a minimum of 16 gage galvanized steel formed into a structural hot channel shape with tabbed corners for reinforcement.

b. Blades shall be airfoil shaped double skin construction with 14 gage equivalent thickness.

c. Axles shall be 1/2" plated steel hex.

d. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame.

e. Blade edge seals shall be silicone rubber designed to withstand 450^{o}F and jamb seals shall be stainless steel flexible metal compression type.

f. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

g. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under U.L. Standard 555, and shall further be classified by U.L. as a leakage rated damper for use in smoke control systems under the latest version of U.L. Standard 555S, and bear a U.L. label attesting to same. Damper manufacturer shall have tested, and qualified with U.L., a complete range of damper sizes covering all dampers required by this Specification. Testing and qualifying a single damper size is not acceptable. The leakage rating under U.L. 555S shall be no higher than leakage class 1 (4 cfm/ft^2 at 1" w.g. and 8 cfm/ft^2 at 4" w.g.).

h. Dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 4000 fpm air velocity in the open position.

i. The combination fire/smoke dampers and their actuators shall be

qualified under U.L. 555S to an elevated temperature of 350°F. Appropriate pneumatic actuators shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity which meets all applicable U.L. 555 and U.L. 555S qualifications for both dampers and actuators.

j. Dampers shall be Model FSD60 low leakage combination fire/smoke dampers as manufactured by Ruskin or approved equal. Dampers shall be provided with adjustable balancing settings where required or noted on the drawings.

11. Air Flow Measuring Stations:

a. Air flow stations for ducts and fan inlets shall be self-averaging traverse array measuring devices.

b. Device specifications shall comply with the following:

Accuracy	+/- 2% to 3%
Calibrated Range	0-5000 fpm

c. The maximum allowable pressure drop shall not exceed 0.015" wg at 1000 fpm.

d. Device shall be Advantage Gold Series by Ebtron with Model GP1 sensor for duct mounted locations and GF1 for fan inlet mounted sensors, gold anodized 6061 aluminum alloy tube, and 316 SST mounting brackets. Transmitter shall be electronic type with LCD display, 24 VAC power required, and 4 to 20 MA output.

E. Wiring:

1. Power Wiring: All 120 VAC power wiring shall be minimum #12 AWG as specified in Division 26 - Electrical.

2. Control Wiring:

a. All sensor and control signal wiring shall be a minimum #18 AWG or twisted shielded pair (TSP) as required.

b. Thermostat phone jack connectors shall be eight- conductor, #24 AWG, plenum-rated telephone cable with 8-pin RJ-45 connectors.

c. Communication wiring for network communication shall be Category 5 premises cable for high speed LAN applications. Cable shall conform to UL444, ICEA S-80-576, and TIA/EIA (TSB-36).

F. Conduit:

1. Unless noted otherwise, all power and all control wiring shall be routed in conduit. Plenum rated communication cable above ceilings may be

routed without conduit.

2. Conduit shall be in EMT (3/4" trade size minimum) conduit utilizing compression fittings. Set screw couplings shall not be used on control work.

3. Intermediate or rigid conduit shall be utilized for exterior application or as detailed. IMC and rigid conduit shall use screwed couplings with watertight joints.

G. Transformers:

1. Controls Contractor shall provide 120 VAC wiring from nearest power source for control power requirements.

2. Transformers shall be selected by the Controls Contractor for 24 VAC secondary voltage as required baud on primary voltages of 120 VAC, 208/240 VAC, 277 VAC, and 480 VAC.

3. Transformers shall be NEC Class 2, energy limiting or step-down type as required.

d. Secondary side shall have fuse protection.

H. Current Transmitters:

Output:	4-20 mA
Supply Voltage:	5-40 volts DC
Accuracy:	+/- 0.5% of full scale
Repeatability:	+/- 0.1% of full scale
Protection:	Reverse voltage protection; high over-current protection

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION: Prior to executing the work, carefully inspect the installed work of other trades and verify that all such work is complete and to the point where the control systems may be installed without damage. Coordinate with other trades.

3.02 INSTALLATION: All work shall be installed in strict accordance with the Drawings and Specifications by personnel directly in the employ of the Controls Contractor or his subcontractors.

A. It is noted that the Drawings and Specifications describe the approximate locations of the work. Do not scale the Drawings to determine exact positions and clearances. Obtain from the Owner's representative any dimensions not shown.

B. Bring to the attention of the Owner's representative immediately any changes in the size or location of the material or equipment which may be necessary in order to meet field conditions, or in order to avoid conflict with the equipment

of other sections of the Specifications. Obtain the Owner's representative's approval before such deviations are made.

C. Details of construction and of workmanship where not specifically described herein or indicated on the Drawings shall be subject to the Owner's representative's approval. It is the intent of these Specifications to provide complete systems, left in good working order, ready for operation, including necessary labor and materials, whether or not specifically shown on the Drawings or mentioned herein.

D. Obtain from the Owner's representative at the site the location of any apparatus not definitely located on the Drawings. Locate equipment and accessories in such a manner as to provide easy access for proper service and maintenance. Special care is required to provide accessibility to openings in equipment requiring maintenance. Bring to the attention of the Owner's representative any condition which prevents adequate accessibility for maintenance, prior to installation of that work.

E. Mounting of field microprocessors on air handling units shall not be allowed.

3.03 CONDUIT:

A. All control and power wiring shall be routed in conduit.

B. Conduit Supports:

1. Single runs shall use galvanized conduit straps or ring bolt type hangers with specialty spring clips. Plumber's perforated straps are not allowed.
2. Multiple runs shall use conduit racks with 25% spare capacity.
3. Vertical runs shall use channel support with conduit fittings.

C. Anchor Methods:

1. Hollow masonry shall have toggle bolts or spider type expansion anchors.
2. Solid masonry shall have lead expansion anchors or preset inserts.
3. Metal surfaces shall have machine screws, bolts, or welded studs.
4. Wood surfaces shall have wood screws.
5. Concrete surfaces shall have self-drilling anchors or power drive studs.

3.04 CONTROL PIPING AND TUBING: Control tubing shall be installed in a neat and workmanlike manner by trained mechanics in the direct employ of the control manufacturer per accepted industry standards.

A. All tubing and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces. Tubing may be run exposed in mechanical rooms or areas where other piping is exposed. Tubing shall be adequately supported to eliminate drooping or sagging.

B. Hard or soft drawn copper tubing, shall be used where buried in construction.

C. Tubing in equipment rooms, where exposed, shall be installed as hard copper tubing or polyethylene tubing in raceway conduit. Single terminal lines in equipment rooms shall be hard copper.

D. The piping system shall be leak tested by placing it under 25 psig pressure for a period of 2 hours. The pressure drop during the period shall not exceed 2 psig.

3.05 ELECTRICAL: The control system shall be installed according to the following provisions. All electrical work shall be installed in accordance with Division 26 - Electrical.

A. Power wiring for the control system shall be provided to the general location by the Electrical Contractor. Designated circuit breakers shall be furnished by the Electrical Contractor in the distribution panelboards for the control systems. Feeders shall be run to junction boxes by the Electrical Contractor as shown on the plans and control diagrams.

B. ELECTRICAL POWER shown on Electrical Drawings shall be provided to a local junction box by the Electrical Contractor. Wire, conduit, and connections to supply power to terminal units, panels, transformers, remote devices, and the like, shall be provided by the Controls Contractor.

C. All limited energy cable installed under this specification shall be UL listed and labeled for the specific use.

D. All wiring shall be in conduit. (All Junction Box covers shall be blue and have the word "CONTROLS" painted on them -- 3/8" high or larger.)

E. All electrical wiring shall comply with the National Electrical Code, Project Specifications, and shall be installed by licensed journeyman electricians.

F. Low voltage and line voltage wiring shall be installed in separate conduits.

G. All interlock and control wiring for the HVAC systems not shown on the Electrical Drawings shall be by the FMS Controls Contractor. This may include but not be limited to:

1. Sensor and transmitter wiring to DDC panels.

2. Safety interlocks to the starters, i.e. low and high pressure safety switches, smoke detector shut-down contacts, start/stop functions, and limit controls.

3. Wiring of thermostats or factory prewired panels furnished by others to control fans, and the like.

4. Trunk communication wiring.

5. Transformers, contactors, relays, and miscellaneous wiring and mounting.

3.06 WIRING SUPERVISION AND CHECKOUT: Supervision and checkout of the system shall be by factory trained engineers and technicians directly employed by the FMS Controls Contractor.

3.07 WORK BY OTHERS: The following work related to this Section shall be performed as

follows:

A. Automatic control valves, orifice plates, flanges, separable wells for immersion elements, and the like furnished by the FMS Controls Contractor shall be installed by the Mechanical Contractor under the FMS Controls Contractor's supervision.

B. Automatic dampers furnished by the Mechanical Contractor in ductwork and casings, and air flow measuring stations furnished by the FMS Controls Contractor, shall be installed by the Mechanical Contractor under the FMS Controls Contractor's supervision. It shall be the responsibility of the Mechanical Contractor to see that the dampers are correctly installed so that they operate freely and close tightly. It shall be the responsibility of the Mechanical Contractor to provide and install blank off plates when the control application requires dampers smaller than duct size.

C. Any finish painting required for control piping and control equipment shall be done by the FMS Controls Contractor.

D. Duct mounted smoke detectors shall be furnished by the Electrical Contractor, installed by the Mechanical Contractor, and wired by the Electrical Contractor.

E. Relays for interface with the Fire Alarm System shall be furnished, installed and wired to the Fire Alarm Control Panel by the Electrical Contractor.

3.08 INSTRUCTIONS AND ADJUSTMENT:

A. Upon completion of the project, the Controls Contractor shall have completely adjusted and calibrated the entire control system to operate as described in this section of the Specifications. The Contractor shall arrange to provide instruction to the Owner's personnel as part of the commissioning phase.

B. The Contractor shall submit to the Owner's representative six (6) sets of as-built drawings, and operating and maintenance manuals, to be approved and delivered to the Owner.

C. The Contractor shall obtain from the Owner a signed receipt that Owner's personnel have received complete instruction on the operation of the system.

D. Operator training shall include:

1. Sequence of operation review.
2. Sign on-Sign off.
3. Selection of all displays and reports.
4. Commanding of points, keyboard and mouse mode.
5. Modifying English text.
6. Use of all dialogue boxes and menus.
7. Modifying alarm limits and start-stop times.
8. System initialization.
9. Download and initialization of remote panels.
10. Purge and/or dump of historical data.
11. Use of portable operators terminals.
12. Troubleshooting of sensors (determining bad sensors).
13. Password modification.

14. Creation and modification of cardholder database.

E. Supervisor training shall include a two-hour session encompassing:

1. Password assignment/modification.
2. Operator assignment/modification.
3. Operator authority assignment/modification.
4. Point disable/enable.
5. Terminal and data segregation/modification.
6. Use of portable operator terminal.
7. Use of spreadsheet package with system data.
8. Creation and modification of site-specific user-defined cardholder fields.

F. Programmer training shall include at least eight hours of training encompassing:

1. Software review of Sequence of Operation and flowcharts.
2. Use of diagnostics.
3. System maintenance procedures.
4. Review of initialization.
5. Upload/download and off-line archiving of PCP and PC system software.
6. Graphic creation.

Programmer training shall be for two Owner personnel and shall be scheduled by the Owner with two-week notice anytime during the warranty period.

3.09 VALIDATION:

A. The FMS Controls Contractor shall completely check out, calibrate, and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

B. Witnessed validation demonstration shall consist of:

1. Running each specified report.
2. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
3. Step through penetration tree, display all graphics, demonstrate dynamic update and direct access to graphics.
4. Execute digital and analog commands in graphic mode.
5. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
6. Demonstrate FMS performance via trend logs and command trace.
7. Demonstrate scan, update, and alarm responsiveness.
8. Demonstrate spreadsheet/curve plot software and its integration with the database.
9. Demonstrate on-line user guide and help function.
10. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
11. Demonstrate multi-tasking.
12. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving and color banding.

3.10 MANUALS: The following manuals shall be provided:

A. An Operator's Manual with graphic explanations of operator functions. Although operator functions are to be self-instructional and menu-interactive from the keyboard terminal, this manual shall be for off-line study and refresher use.

B. Computerized printouts of all data file construction including all point processing assignments, physical terminal relationships, flowcharts of graphic program, etc.

C. A user manual for the integrated spreadsheet package.

D. Four (4) Operator's Manuals and four (4) As-Built Manuals shall be provided to the Owner.

3.11 SEQUENCES OF OPERATION:

A. General:

1. Hand-Off-Auto: The HOA switches shall be located locally at the units and shall be readily accessible. In the "Auto" position, the equipment shall be under the control of the FMS. In the "Hand" position the equipment shall operate independent of the FMS. In the "Off" position the equipment shall shutdown independently of the FMS or other remote control. Safety controls and FACP shutdown contacts shall shutdown fans with the HOA switch in any position.

2. Status: Proof of operation shall be by a current sensing relay installed on the power wiring or motor starter. An alarm shall be generated when the motor is enabled and the current sensing relay does not detect sufficient current to indicate a run status.

3. Thermometers: Temperature gages shall be permanently installed in the functional location shown on the control diagrams on the Drawings.

4. All system setpoints shall be adjustable as the Owner may find that setpoints may need to be adjusted to suit building operating conditions.

B. DEDICATED OUTDOOR AIR SYSTEM (DOAS)

The DOAS shall be indexed to run only during occupied hours for the building. During unoccupied hours, the DOAS shall remain off (supply fan and exhaust fan shall remain de-energized, exhaust and supply dampers shall remain closed).

In occupied mode, the controller shall index the DOAS to run via a field relay contact wired in series with the unit's low voltage control circuit. When the DOAS is indexed "on" for the occupied mode, the DOAS controls (furnished with the unit) shall index the supply and exhaust dampers "open" and index the supply and exhaust fans "on" via internal interlocks. Once indexed to run, the DOAS shall run subject to internal controls and safeties until the end of the occupied cycle.

Provide graphical display for the following points (minimum points as shown below):

1. Unit start/stop interface
2. Outdoor air temperature
3. Supply air temperature
4. Supply air humidity
5. Fan status
6. Filter status
7. Alarm status

C. VRF SYSTEMS

The VRF Systems Controller shall integrate with the FMS via BACNET module. The FMS shall provide for override of operation modes, setpoints and schedules.

Provide graphical display for the following points (minimum points as shown below):

1. Unit operation mode
2. Zone setpoint temperature
3. Zone temperature
4. Alarm status

END OF SECTION

SECTION 23 20 10
PIPE, PIPE FITTINGS, AND VALVES

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 RELATED WORK: Related work specified elsewhere:

A. Division 23 - Insulation

1.03 DEFINITIONS:

A. Design pressure of a zone of piping is the maximum pressure that can be predicted to occur in that zone, from an analysis of Drawings. Design pressure is not normally indicated on Drawings. Consult the Engineer if the design pressure for a particular zone is in question.

B. Flanging refers to the roll-back operation to form a flange using the pipe wall. It shall not be construed as the welding of a flange fitting to the end of a pipe, the coupling of pipes, or the coupling of pipes and fittings by means of flange fittings.

C. Furnace butt welded (or butt welded) pipe refers to a particular pipe manufacturing process. The term shall not be construed as the joining of steel pipe by means of a butt weld, or as the suitability of a particular type of pipe for butt welding.

D. Outside shall mean 5 feet beyond the perimeter of buildings.

E. Inside shall mean inside buildings and within 5 feet of the perimeter of buildings, except that footing drains are excluded.

F. Protected pipe refers to the coating or covering of an uninsulated pipe to make it suitable for exposure to outside weather, for direct burial in dry or wet earth, or for submarine installations in direct contact with water.

1.04 SUBMITTALS: Submit shop drawings in accordance with Section 23 0010 - Mechanical General Provisions:

A. Manufacturer's Certificate of Compliance.

B. Piping (Submit product data, construction and materials compliance data, dimensional data, and Country of origin for piping required by the Specifications for use on this project.)

C. Valves (Submit product data, construction and materials compliance data, dimensional data, and Country of origin for each valve or valve specialty type required by the Specifications for use on this project.)

PART 2 - PRODUCTS

2.01 PIPE, PIPE FITTINGS, VALVES AND ACCESSORIES shall be as listed in Section 23 2012. All pipe, pipe fittings, valves and installation accessories shall be manufactured in the USA. If USA manufactured valves are not available from the manufactures listed below, provide equivalent valves from one of the manufacturers listed.

2.02 PIPE FITTINGS: Welded, flanged, screwed, brazed, or soldered fittings for ferrous or copper piping shall be as manufactured by Crane, Nibco, Walworth, Stockham, Grinnell, Mueller, Weldbend, Tube Turns, or Chase and shall meet the requirements of the standards specified in the Piping Schedules. Threadolets and weldolets shall be Boney Forge, or equal.

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION:

A. Prior to all piping work, carefully inspect the work by other trades and verify that all such work is complete to the point where the piping may be installed in accordance with these documents.

B. Prior to all piping work, carefully inspect all existing conditions to verify that the piping may be installed in accordance with these documents.

C. Follow the Drawings in layout work and check drawings of other trades to verify sufficient space to install piping.

D. Undimensioned Drawings are intended to indicate the general arrangement of piping systems and are not intended to convey precise locational information.

E. Coordinate with other trades to permit the work of all trades to be installed.

F. Coordinate the work to insure that supports, sleeves and inserts are positioned accurately along with other built-in items, before concrete pouring takes place, so as to reduce to an absolute minimum the necessity for cutting or patching at a later stage.

G. Offsets, fittings, and extra pipe necessary to avoid interference, or provide maximum headroom and space shall be furnished and installed without additional expense to the Owner.

H. If the piping is installed without coordinating with other trades and interferes with work of other trades, the necessary changes shall be made at no extra charge.

I. The Drawings are generally diagrammatic and may not indicate all off-sets, fittings, and accessories which may be required. The Contractor shall investigate all potential obstructions carefully, plan ahead, and provide at no additional cost to the Owner such fittings, valves and accessories as may be required to meet such conditions.

3.02 INSTALLATION:

A. Excessive cutting and similar operations likely to weaken a structure or support to facilitate piping installation will not be permitted.

B. Prevent trash and dirt from entering pipes, before, during, and after installation, taking care and implementing suitable control measures throughout the construction period. Temporarily plug pipe ends as construction progresses, and until final connections are made.

C. Run piping parallel to walls of building, adjacent piping, fencing and the like, unless otherwise indicated.

D. Where pipe is to be insulated, provide a clearance equal to the insulation thickness plus a minimum of 2 inches.

E. Piping shall be worked in place without springing or forcing, and so as to properly clear all openings and equipment.

F. Piping shall be installed to permit free expansion and contraction without damage to joints or supports.

G. Thermal expansion of pipe shall be provided for in accordance with good trade practices. Use swing joints, turns, expansion loops, or long offsets, anchors and guides, as necessary to allow for and control pipe movement in accordance with ANSI B31.1.

H. Piping connections to equipment shall be installed in such manner that no excessive stresses will be transferred from the piping system to the equipment either during construction or operation.

I. Steel members shall be installed as required to support and anchor pipelines. Supports, anchors, or stays which may deform or alter the shape of the piping, during or after installation, shall not be used.

J. All changes in size and direction shall be made with proper pipe fittings; no miter fittings or joints will be accepted without prior approval of the Engineer.

K. Notching of copper tubing or plastic piping for connections will not be permitted.

L. All piping shall be cleaned and blown out just before installation.

M. Provide globe, ball, or butterfly type valves for throttling or drain service.

N. Valves shall be installed with stems vertical, horizontal or inclined upward. Valves shall not be arranged with stem below body.

O. Protect all water systems against freezing throughout the progress of the installation until final acceptance.

P. All water piping shall be protected in an approved manner from freezing at any future time under normal operating circumstances.

Q. All water piping shall be installed in such a manner that the entire system can be completely drained.

R. Protect pipes which are to receive a vapor barrier insulation from pipe hangers by using pipe saddles specifically designed for this purpose.

S. Provide dielectric isolation of connections between dissimilar metals.

T. Horizontal drain and waste piping within the building shall be given a grade of 1/4" per foot where possible but no less than 1/8" per foot. Piping 3" and smaller shall have minimum grade of 1/4" per foot. Main vertical soil and waste stacks shall be extended full size to the roof line and 12" above as vents, unless otherwise indicated on the Drawings. Fittings shall be service weight when used on service weight pipe. Fittings in extra heavy pipe shall be extra heavy weight. Reduction of the size of drainage piping in the direction of flow is prohibited. The use of double hubs, sleeves, inverted caulk joints, sanitary crosses, drilling and tapping of house drains, soils, waste or vent pipes and the use of saddles are prohibited.

U. Piping, including sanitary waste and vent piping, shall be installed straight and true to vertical and horizontal lines, with uniform slope for waste, vent, and drain lines. Deflection shall not exceed one degree. When necessary to achieve this alignment, provide additional hangers or bracing.

V. Slip joints of plumbing trap seals shall be used on inlet side only.

W. All flush valves shall be adjusted to give adequate but not excessive flushing action and shall be adjusted to operate as quietly as practical without sacrificing complete flushing action.

3.03 LAYOUT, CUTTING, AND FITTING UP:

A. Pipe and tubing shall be cut accurately to suit field conditions.

B. Pipe ends that are to be butt welded shall be beveled in accordance with ANSI B16.25.

C. Burrs shall be removed by reaming and other objectionable defects shall be removed by machining, chipping, or grinding.

D. Laterals ("Y" fittings) shall be used for branch connections in drainage piping, unless otherwise indicated.

3.04 CONCEALED PIPE:

A. In general, all pipe in finished spaces shall be run concealed in floors, walls, partitions and above ceilings.

B. Concealment and covering of pipe shall not be done until authorized by the Engineer, after proper tests have been made. This applies to all interior work and exterior work.

3.05 OPENINGS, SLEEVES & FLASHINGS:

A. Pipe sleeves shall be provided where pipes pass through walls, floors or partitions. Sleeves through floors shall be Schedule 40 steel pipe set flush with

bottom of slab and shall extend approximately 2" above the finished floor. Sleeves through partitions shall be Schedule 40 steel pipe flush with both sides of walls or partitions, and coated with rust inhibitive paint. Sleeves passing through concrete or masonry walls shall be Schedule 40 steel pipe set flush with the wall on both sides. Seal piping penetrations thru outside walls and floor for weatherproofing and leak tight.

B. Sleeves for insulated pipes shall be large enough to accommodate insulation and to permit expansion movement. Sleeves shall be larger in dimension that the outside diameter of insulation. Insulation shall be continuous through sleeves.

C. Support pipe from building structure where pipe penetrates walls to prevent resting on building wall or skin.

D. Where pipes penetrate firewalls, fire partitions, or fire rated floors, provide U.L. approved firestop seal between pipe and pipe sleeve in accordance with Section 23 0529, Supports, Anchors & Seals. Pack all other spaces between sleeves and insulation or pipe with fiberglass to make airtight unless indicated otherwise by U.L. approved installation methods.

E. When available to meet the same objectives described above, prefabricated, preinsulated "Pipe Shields" will be acceptable for pipes passing through floors, exterior walls, fire walls and fire resistive walls and partitions.

3.06 WELDED JOINTS:

A. Welded joints between sections of pipe and between pipe and fittings shall be in strict compliance with ANSI B31.1, Chapter 5, Section 127.

B. Each welded joint shall be stamped with the individual welder's identification number. See Quality Assurance in Part 1 of this section.

C. Make joints in piping for all services tight and leakproof against the design pressure.

D. Peening of welded joints to correct leaks will not be permitted.

E. Carbon steel pipe welding shall be done by the manual metal arc process using coated electrodes or gas arc (GMAW) process. All socket welds shall be made by manual metal arc processes.

F. Heat Treatment of Welds: No preheating of carbon steel piping is required, except no welding shall be performed on metal colder than 32^{o}F.

G. Welding shall penetrate the full wall thickness of the pipe. Slag shall be cleaned from each weld layer and any serious defects removed before the next layer is applied. The completed weld shall be cleaned of slag.

H. Preparatory to final welding, the proper gap shall be maintained while tack welding the pipe and connections in position so that a proper gap is made for a full penetration weld.

I. Tack welds shall be of the same quality and made by the same process as the rest of the weld, or they shall be removed prior to completion of the weld.

J. Small, sound, tack welds which penetrate to the bottom of the welding grove may become a part of the finished weld. Tack welds lacking penetration are not acceptable and must be removed. Large tack welds which almost fill the welding groove are not acceptable and must be removed.

K. Branch connection joints shall be prepared so as to permit full penetration welds of a quality comparable to the circumferential welds in the same piping system.

L. Permanently welded-in back-up strips shall not be used.

3.07 SOLDERED JOINTS:

A. Soldered joints between sections of pipe and pipe fittings shall be made using factory solder fittings with proper clearances between surfaces.

B. Immediately before soldering, thoroughly clean and burnish the joints with a crocus cloth or fitting brush especially made for this purpose.

C. Apply a suitable flux over the cleaned surface and apply heat with an air-acetylene or oxy-acetylene torch.

D. Use tin/silver solder as specified for material system. Solder containing lead, acid core solder or acid flux shall not be used.

E. Remove residue from flux.

F. Joints that leak shall be disassembled, cleaned and made again.

3.08 THREADED JOINTS:

A. Piping specified to be joined by threading shall be cut square to accurate lengths, and after threading shall be reamed to remove burrs and to provide full flow diameter of pipe through the joint.

B. Threads shall be cut full, clean, and concentric with the outside of the pipe. Threads shall be in accordance with ANSI B2.1 for taper threads.

C. Remove excess thread cutting lubricant from the inside and outside of pipe.

D. Threaded joints shall be made leak-tight by use of a suitable joint compound or teflon tape for pipe threads. (No. 51 Permatex pipe joint compound or equal), except as otherwise required by attached Piping Schedules.

E. When assembled, not more than three threads shall be visible at any joint.

F. Make joints in piping systems tight and leakproof against design pressures.

G. Care shall be taken to avoid over-tightening of threaded joints and to avoid damaging the pipe exterior with the pipe wrench.

H. Backing off of made-up threaded joints to facilitate fit-up or alignment will not be permitted.

I. Repair leaks in screwed or flanged joints which cannot be eliminated by normal wrench tightening methods by remaking the joint. Caulking will not be allowed.

3.09 FITTINGS:

A. Reducers: Make changes in pipe size by using factory made reducers. Use eccentric reducers in horizontal gravity flow systems with the flat side on bottom. Bushings, victaulic reducing couplings and field made reducers will not be permitted.

B. Tees, weldolets, sockolets and threadolets, or factory made tee fittings, shall be used for branch connections when the diameter of the branch connection does not exceed 50% of the diameter of the main; otherwise, factory made tee fittings shall be used for tee connections.

C. Elbows shall be factory made long radius type.

D. Unions: Install unions on each side of all threaded special valves, threaded regulators and similar items, on one side of each threaded check valve and at all pieces of unflanged equipment, so that such equipment might be readily disconnected and removed. Unions shall not be placed in a location which will be inaccessible after completion of the work.

E. Gaskets: Assemble flanges with gaskets specified in Piping Schedules at the end of this section.

3.10 LEAK TESTING OF PIPING SYSTEMS: Perform leak tests according to the applicable paragraphs in Section 23 05 93 - Tests.

3.11 CLEANING OF PIPING SYSTEMS:

A. The interior surfaces of piping shall be smooth and entirely free from obstructions to flow. Clean the systems before connecting to equipment or other systems.

B. Thoroughly clean all hot and chilled water piping systems using an alkaline cleaner, mixed in accordance with the manufacturer's recommendations. Where possible, heat the cleaning solution to approximately 160^{o}F and circulate for at least 24 hours in the system. When heat cannot be applied, circulate the cleaning solution for at least 48 hours. Afterwards, drain and flush entire system before refilling for final system start-up and operation.

3.12 PIPING SYSTEMS FILL AND START-UP:

A. After cleaning heating water and chilled water piping systems, refill each system with city water and install corrosion inhibitor and biocide water treatment chemicals as recommended by the chemical treatment supplier.

B. The Contractor shall notify the Engineer at least 48 hours prior to filling or adding chemicals to chilled water and heating water systems.

END OF SECTION

SECTION 23 2012
PIPING SCHEDULE - SERVICE & MATERIAL SYSTEM

I.D.	DESCRIPTION	OPERATING PSIG	OPERATING °F	MATERIAL SYSTEM	INSULATION SYSTEM	NOTES
CD	Condensate Drain, Cooling	ATM.	45	CP/3,PV1	C	1,3,4,5
RS	Refrigerant	Per Equipment Manufacturer Requirements				
RL	Refrigerant	Per Equipment Manufacturer Requirements				

REFERENCED NOTES:

1. Use rigid tubing and fittings for all copper piping.

2. Not used.

3. A continuous vapor barrier and a continuous insulation thickness, including all joints, fittings, valves, equipment and accessories, is required and is extremely important to prevent condensation.

4. Insulation thickness on condensate drain lines indoors serving air conditioning equipment shall be ¾ inch thick regardless of pipe diameter.

5. Exposed condensate drains on roof shall be schedule 80 PVC routed to roof drains. No insulation is required on drains outdoors.

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PIPE INSULATION SCHEDULE (See Section 23 0700 - Insulation)

System	Description	Pipe Size	Insulation
A (170-220°F)	Molded glass fiber with all service jacket (ASJ). Continuous vapor retarder not required.	1-1/2" & Smaller 2" & Larger	1.5" Thick 2.0" Thick
B (35-70°F)	Molded glass fiber with vapor retarder all-service jacket. Continuous vapor retarder, including sealing of joints, seams, staples, and the like is required.	1-1/2" & Smaller 2" & Larger	1.0" Thick 1.5" Thick
C (35-70°F)	Molded or sheet foamed plastic. Continuous vapor retarder, including sealing of joints, seams and the like is required. Provide finish jacket as scheduled.	1" & Smaller 1-1/4" & Larger	.75" Thick 1.0" Thick
D (35-70°F)	Molded phenolic. Continuous vapor retarder, including sealing of joints seams and the like is required. Provide finish jacket and/or finish as scheduled. Can be used up to 3” thickness in air plenums where 25/50 flame and smoke rating is required.	All Sizes	1.5" Thick

PIPING SCHEDULE - MATERIAL SYSTEM CP/3

Pressure Design: Atmospheric (For gravity drain systems) Temperature Design 100°F.

ITEM	SIZES	MATERIALS
Pipe	1-1/4" to 4"	ASTM B-88, Type L, Seamless, Hard Drawn Copper Tubing (above grade), Copper UNS Number C10800 (maximum 0.012 percent phosphorous). ASTM B-88, Type K, Seamless, Hard Drawn or Soft Annealed Copper Tubing (below grade), Copper UNS Number C10800 (maximum 0.012 percent phosphorus).
Fittings	1-1/4" to 4"	ANSI B16.29, Wrought Copper and Wrot copper Alloy Solder Joint Drainage Fittings - DWV or ANSI B16.23, Cast Copper Alloy Solder Joint Drainage Fittings - DWV
Flanges	ALL	ASTM B-62 and ANSI B16.18, Cast Brass, 125 lb., Flat Face, Socket Type Solder Joint.
Unions Threaded	1-1/4" & Larger	ASTM B-62 and ANSI B16.18, Cast Brass, Ends.
	1" & Smaller	ASTM B-62 and ANSI B16.18, Cast Brass, Solder joint.
Joints	Flanged	Garlock Full-Face Gasket
	Threaded	Commercial Grade Pipe Dope or Teflon Thread Tape.
	Solder	96/4 Tin-Silver (430° melting point, low temp.) for all services.
Studs & Nuts	ALL	ASTM A-307, Grade B, Zinc Plated Hex Head Machine Type.

PIPING SCHEDULE - MATERIAL SYSTEM PV/1

Pressure Design 160 psig at 73°F. Temperature Design 120°F

ITEM	SIZES	MATERIALS
Pipe	8" & Larger	Polyvinylchloride (PVC) pressure rated SDR 26 thickness Standard Dimension Ratio per ASTM D2241, for underground installation. PVC shall be Type I, Grade 1 per ASTM D1784.
Joints	PVC/PVC	Bell and spigot pipe ends with rubber 'O' ring gasket seals per ASTM D1869.
Joints	PVC/Steel	Ductile iron mechanical joint flange on PVC pipe with rubber gasket seal, AWWA C110 and AWWA C111, to mate with standard pipe flange.
Fittings	≤8"	Ductile iron mechanical joint each end with rubber gasket seals, Larger AWWA C110 and AWWA C111.
Anchors	>8"	Anchor connecting steel piping within 5 feet of connection point to eliminate any thrust, stress or torque from the steel pipe being transferred to the PVC pipe.
Thrust Blocks	ALL	Provide concrete thrust blocks at all changes of direction to prevent joints and fittings from being forced apart. Properly size thrust blocks to suit the forces involved and the bearing capacity of the soil.
Backfill	ALL	Tamp in place in six inch lifts. See details on drawings for dimensions and bedding materials. No rock shall be in the first foot of backfill above the pipe. Two feet of backfill, between top of pipe and grade, shall meet H-20 Highway Loading.
Testing	ALL	Hydrostatically test before backfilling at 120 psig for 4 hours, with no pressure loss except that due to ambient temperature change.

END OF SECTION 23 20 12

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 REFERENCES: (Latest edition for listed references shall apply.)

A. ASHRAE Handbook - Fundamentals (latest edition): Duct Design chapter.
B. ASHRAE Handbook - Equipment (latest edition): Duct Construction chapter.
C. ASTM A90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
D. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
E. ASTM A480 - Standard Specification for Stainless Steel Sheet, Plate and Strip.
F. ASTM A525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
G. ASTM A527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
H. ASTM B209 - Aluminum Alloy Sheet and Plate.
I. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
J. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
K. SMACNA - Duct Construction Standards.
L. SMACNA - Fire, Smoke and Radiation Damper Guide for HVAC Systems.
M. UL 181 - Factory-Made Air Ducts and Connectors.

1.3 STANDARDS: Duct systems shall be in accordance with SMACNA Duct Construction Standards, the National Fire Protection Association, the North Carolina State Building Code, and manufacturer's recommendations where applicable.

1.4 SHOP DRAWINGS: Submit shop drawings of the following:

A. Ductwork layout and dimensions at minimum scale of 1/4" = 1'-0". (Refer to Section 23 00 10 - Mechanical General Provisions).

B. Construction details for special fabrications.

C. Ductwork accessories.

1.5 DUCTWORK MATERIALS:

A. HVAC Ductwork (General):

1. All HVAC ductwork, hangers, supports, and insulation shall be as scheduled in Section 23 31 15 and as indicated on the Drawings.

2. All galvanized steel HVAC ductwork, hangers, and supports exposed outdoors or exposed indoors in areas scheduled to receive finish painting shall be constructed of galvanized steel with "paint-grip" or similar mill surface etch treatment to create a paintable galvanized surface. Refer to Section 23 31 15 - Ductwork Schedule for materials

required at each location.

3. All low pressure insulated flexible ductwork shall meet the requirements of UL-181 Class 1 Air Duct, NFPA 90A and 90B, and the requirements of this Specification Section.

1.6 PRESSURE-VELOCITY CLASSIFICATION OF DUCTWORK: Classifications shall be according to Table 1-1 in the SMACNA HVAC Duct Construction Standards - Metal and Flexible - latest edition, the notes on the Drawings, and the schedules in Section 23 31 15 - Ductwork Schedule - Service and Material System.

1.7 DUCTWORK SEALING REQUIREMENTS

A. Sealing requirements shall be according to Table 1-2 in the SMACNA HVAC Duct Construction Standards and the information on the Drawings. Refer to Section 23 31 15 - Ductwork Schedule Service and Material Systems. Oil based caulking and glazing compounds shall not be used. Refer to Part 2 - Products of this Section for duct sealant specifications.

B. HVAC and Exhaust Air Ductwork:

1. Refer to Drawings and Section 23 31 15 - Ductwork Schedule for information on duct Seal Class requirements for specific duct systems.

2. Where not indicated on the Drawings or in schedules, the following duct sealing requirements shall apply:

a. One inch (1") water gauge pressure class ductwork shall meet Seal Class C.

b. Two inch (2") water gauge pressure class ductwork shall meet Seal Class B.

c. Three inch (3") and higher water gauge pressure class ductwork shall meet Seal Class A.

1.8 OFFSETS, BENDS, AND RELATED WORK: The Drawings covering the work of other trades, and all work already installed, shall be thoroughly examined and arrangements made to provide all necessary offsets, bends, or changes, including duct enlargements and streamlined pipe and hanger rod casings, as required to resolve and eliminate conflict with other trades.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Galvanized steel shall meet requirements of ASTM A90, ASTM A525 and ASTM A527, "Steel Sheet, Zinc Coated by the Hot-Dip Process, Lock-Forming Quality", based on G-90 coating.

C. Aluminum shall meet requirements of ASTM B209, "Aluminum Alloy Sheet and Plate," and shall be suitable for welding of duct joints.

D. Stainless steel shall be 300 series and shall meet requirements of ASTM A167 "Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip". Finish shall be as specified or scheduled, according to requirements of ASTM A480.

E. Insulated, low pressure flexible ductwork shall conform to the requirements of UL 181 and the requirements of this Specification Section.

F. Fasteners, such as rivets, bolts, or sheet metal screws, shall be of same material as duct system. Fasteners for galvanized steel shall be cadmium plated or galvanized steel, as appropriate for the Exposure Classification.

2.2 SUPPORTS AND HANGERS

A. Materials and Finish for supports, hangers, fasteners, and accessories shall be as scheduled for "hangers" in Section 23 31 15, and shall comply with the following:

1. System "BS" (black steel) shall be ASTM A-36 carbon steel with black or plain mill finish. Components shall be cleaned and painted with primer after fabrication. Primer shall be touched up after installation. Primer color shall be selected by Owner's representative.

2. System "GN" (galvaneal steel) shall be constructed of galvanized steel with "paint-grip" or similar mill surface etch treatment to create a paintable galvanized surface.

3. System "GS" (galvanized steel) sheet materials shall meet requirements of ASTM A90, ASTM A525, and ASTM A527, "Steel Sheet, Zinc Coated by the Hot-Dip Process, Lock-Forming Quality", based on G-90 coating. Hanger rods, rolled-shapes, and other parts shall be ASTM A-36 carbon steel with ASTM B633 SC1 or SC3 electro-plated zinc finish.

4. System "AL" (aluminum) sheet and formed shapes shall meet requirements of ASTM B209, "Aluminum Alloy Sheet and Plate," and shall be suitable for welding. Hanger rods, fasteners, and miscellaneous hardware shall be aluminum, stainless steel, carbon steel coated with Steelcote, or carbon steel coated with PVT Polymer. Galvanized or Cadmium plated steel shall <u>not</u> be used.

5. System "SC" (Steelcote) shall be ASTM A-36 carbon steel with plain finish. All components shall be properly prepared and coated with stainless steel filled urethane coating on all surfaces for corrosion resistant finish.

6. System "SS" (stainless steel) shall be 300 series and shall meet requirements of ASTM A167 "Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip". Finish shall be as specified or scheduled, according to requirements of ASTM A480. All components, including hanger rods, fasteners and hardware, shall be stainless steel.

B. Shop Coating Systems:

1. Shop Primer: Standard shop primer equal to Steel Structures Painting Council (SSPC) Specification No. 13. Total dry film thickness shall be not less than 2.5 mils. Verify compatibility of primer with specified finish paint. All miscellaneous steel supports provided for equipment, piping, and accessories furnished under Division 23 Specifications shall be fully coated with approved shop primer paint. Uncoated, bare steel supports will not be accepted.

2. Steelcote: MCU 2100 Type IV stainless steel filled urethane coating for superior abrasion, chemical, and corrosion resistance; 2 coats; 2 mils minimum dry film thickness per coat - 4 mils total. Product shall be manufactured by Steelcote Manufacturing Company.

3. Electro-Plated Galvanized: ASTM B633 SC1 or SC3 coating of zinc on steel by electrolysis from a bath of zinc salts. This coating is pure zinc and adheres to the steel with a molecular bond.

4. PVT Polymer: Highly corrosive resistant coating powder fused to metal; producing a hard, porcelain-like, abrasion resistant finish with good electrical, chemical, and outdoor weathering properties. Product shall be as manufactured by Michigan Hanger Company.

C. Fasteners such as rivets, bolts, or sheet metal screws, shall be of same material as support and hanger system. Fasteners for galvanized steel shall be cadmium plated or galvanized steel.

D. Hanger Rods shall be threaded continuously or threaded each end.

E. Hanger rods shall be subjected to tension only. Lateral and axial movements shall be accommodated by proper linkage in the rod assembly.

F. Support hangers by using malleable iron or carbon steel concrete attachment plates, beam clamps with lock nuts or retaining straps, or other special fastening devices, as required, for the support of hangers. Refer to specific details on the Drawings.

G. Beam Clamps:

1. C-clamps with locknuts shall be used where applicable for hanger rod sizes 3/8" - 3/4" diameter. C-clamps shall be fitted with integral retaining clamps. Clamp assemblies shall be plain carbon steel or electro-plated zinc finish.

2. Side beam brackets for attachment to structural members of wooden beams or trusses shall be malleable iron type with black finish, suitable for attachment using a lag screw; Grinnell Figure 202 or equal. Refer to details on the Drawings.

3. Welded beam attachments shall be used for rod sizes above 3/4" diameter and shall comply with hanger system materials as noted above.

H. Where ductwork cannot be suspended from overhead supports, use substantial welded wall brackets or trapeze supports, as conditions demand and as approved by the Owner's representative.

I. Construct fabricated supports and brackets of structural grade miscellaneous steel and fasteners. Black or plain steel components, which are not specified to have a special finish, shall be delivered to the job site with a prime coat of paint. Touch up primer after fabrication and after installation.

J. Provide all miscellaneous steel, bridging, brackets, anchors, frames, bracing, plates, bolts, nuts, washers, and the like, necessary to properly support ductwork. All steel, hangers and attachments shall be mounted to the building structure, concrete or masonry walls, structural concrete floors or concrete structural members. No attachments of any kind shall be made to the roof deck metal or floor deck metal. Refer to Section 23 00 10 - Mechanical General Provisions for paragraph entitled "Foundations, Supports, Piers, Attachments".

K. Provide bracing and supports for all vertical duct risers, with riser supports at each floor level.

L. Arrangement and fabrication of all supports shall be subject to Owner's representative's approval.

M. Perforated strap hangers and wire hangers will not be permitted, except for temporary supporting during construction. Solid strap hangers shall be permitted where trapeze hangers with angles and hanger rods cannot be installed due to space limitations and specifically approved by the Engineer in writing.

N. Hanging from unreinforced metal roof deck or from cellular roof deck will not be permitted.

O. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of AISC Specification for the Design, Fabrication, and Erection of Structural Steel Buildings.

P. All welds shall be performed by certified welders.

Q. Repaint all existing or new building steel where the paint is scraped or burned away during welding operations to match existing paint finishes.

R. Painting:

1. Immediately after surface preparations, apply shop paint in accordance with manufacturer's printed instructions, and at a rate to provide a uniform dry film thickness as specified.

2. Use painting methods that will result in full coverage of joints, corners, edges, finished welds, and all surfaces.

3. Painting materials and methods shall comply with Specification Section "Painting" in the Contract Documents."

2.3 FITTINGS, DAMPERS AND ACCESSORIES FOR ALL DUCT SYSTEMS shall be of the same material as the adjacent duct. Refer to Section 23 31 15 - Ductwork Schedule.

2.4 FITTINGS FOR FACTORY MANUFACTURED DUCT SYSTEMS shall be of same manufacturer as the duct system with all dimensions and components compatible.

2.5 ROUND ELBOWS AND FITTINGS shall be smooth, stamped type or five-piece type having centerline radius of 1-1/2 times the duct diameter as manufactured by Lindab or Eastern Sheet Metal.

2.6 RECTANGULAR ELBOWS & AIR TURNING VANES (based on SMACNA 1981 Systems Duct Design, Table 6-6):

A. All Ductwork:

1. Elbows in supply, return, exhaust, outside and relief air ductwork shall be SMACNA smooth radius type with two splitter vanes and with a 0.30 minimum inside R/W.

2. Mitered elbows without turning vanes shall NOT be used. Where mitered elbows are absolutely necessary because of space limitation, single thickness SMACNA Type 1 turning vanes with minimum 3/4" long trailing edges shall be provided. Turning vanes shall be same material as ductwork, and shall have same sealing requirement as ductwork.

3. Vanes over 30" long in mitered elbows shall be single thickness as above, with intermediate supports or tie rods, or shall be double thickness airfoil SMACNA Type 1 or 4.

4. Trailing edges of single thickness vanes shall be properly aligned parallel with the duct.

5. The number, size, spacing, and construction details of vanes shall comply with the SMACNA HVAC Duct Construction Standards.

6. Provide splitter vanes of similar construction in duct transitions and other locations, where shown on Drawings.

2.7 DUCT TAPE shall be 4” wide glass fabric tape imbedded in Foster 30-80 vapor barrier, fire resistant adhesive Do not use pressure sensitive tape.

2.8 DUCT SEALANTS shall be tested and labeled in accordance with UL-723 and conform to NFPA-90A Standards. Sealants shall be water soluble and shall exhibit good adhesive strength qualities and lifetime aging characteristics. Flame spread/smoke developed ratings shall not exceed 25/50 when cured. Duct sealant shall be Hardcast Irongrip Water-Based sealant, or approved equal. If a tape or scrim is used in conjunction with the sealant, it shall be compatible with the sealant and shall be recommended by the sealant manufacturer. For ductwork exposed to weather, sealant shall be suitable for outdoor use.

2.9 TRANSVERSE DUCT JOINTS: Transverse joints shall be selected and applied consistent with the static pressure class, applicable sealing requirements, ductwork materials of construction, duct support intervals, and duct reinforcement requirements

in accordance with SMACNA HVAC Duct Construction Standards. Notching, folding, bending and fit-up tolerances shall be appropriate for the composite duct assembly. Joints shall be sealed with approved materials in accordance with SMACNA Duct Sealing Requirements in Table 1-2 in the SMACNA HVAC Duct Construction Standards for the duct static pressure construction class. Bar or angle stock that is incorporated into the transverse joint shall be secured in accordance with SMACNA recommendations. Fasteners shall be appropriate for the ductwork materials of construction and shall be in accordance with SMACNA recommendations.

2.10 TRANSVERSE DUCT JOINTS (PROPRIETARY SYSTEM): (Contractor Option) For transverse joints, 36" wide and larger, transverse duct joints shall be accomplished using components manufactured and supplied by Ductmate Industries, or prior approved equal, and shall comply with the following requirements:

A. All angle steel components shall comply with ASTM A-527 with G90 galvanized finish. All corner steel components shall comply with ASTM A-526 with G90 galvanized finish.

B. Joint sealant materials shall be non-skinning, non-oxidizing product capable of withstanding joint movement without cracking so as to provide an airtight and watertight flexible joint seal. Product shall have maximum flame spread rating of 10, smoke developed rating of 25.

C. Gasket materials shall be Ductmate 440 Tape, or approved equal, and shall be as recommended by the joint system manufacturer. Gasket materials shall be non-skinning, non-oxidizing product capable of withstanding joint movement without cracking or excessive deformation so as to provide a functional airtight and watertight flexible joint seal. Product shall have a maximum flame spread rating of 10, smoke developed rating of 25.

D. Duct joint systems shall have been tested in accordance with SMACNA test procedures with test results certified in writing by an independent testing laboratory. Tests of joint performance shall clearly indicate whether or not an external sealant was applied in conjunction with the manufactured duct joint system.

1. SMACNA Class "J" transverse joints shall be accomplished using the Ductmate '35' Systems as manufactured by Ductmate Industries. The Ductmate '35' Systems shall not be used with duct gauges heavier than 16 gauge or lighter than 26 gauge, in accordance with the manufacturer's recommendations.

2. SMACNA Class "F" transverse joints shall be accomplished using the Ductmate '25' Systems as manufactured by Ductmate Industries. The Ductmate '25' Systems shall not be used with duct gauges heavier than 20 gauge or lighter than 26 gauge, in accordance with the manufacturer's recommendations.

E. All components used to form the transverse duct joint system shall be of standard identifiable catalog manufacture as supplied by Ductmate Industries, or approved equal. All hardware items shall be labeled by the manufacturer so that they may be easily identified as to source of manufacture.

F. The construction of the ductwork, with regards to sheet metal gauge,

reinforcing, seal class, and the like, shall be in strict compliance with the transverse duct system manufacturer's printed installation and applications literature, SMACNA duct construction standards, and the laboratory tested configurations of the duct joint system.

G. The transverse duct joint system shall conform to SMACNA guidelines and requirements for all transverse type joints. Finished joints shall maintain a deflection of less than 0.25" when the system is at standard operating pressure and shall maintain its structural integrity within the operating range of the system. The resulting mid-panel deflection of the joined ductwork sections shall not exceed 0.75" for ducts greater than 24" wide.

H. Transverse spiral and round duct joints may be accomplished with Spiralmate Round Duct Connector and accessory components as manufactured by Ductmate Industries or prior approved equal. Installation of Spiralmate Round Mate Connectors shall be in accordance with the manufacturer's printed instruction and installation manuals. The round connector shall consist of the following components: two mating round duct connector flanges with integral sealant; gasket between the two mating flanges; and a roll-formed closure ring that is drawn tight with a bolt and nut assembly.

I. The manufacturer of the components used to form the transverse duct joint shall guarantee all components against defective materials. The manufacturer shall also have factory trained representatives available to provide field assembly instructions to installing contractors.

J. Installation of all transverse duct joint systems shall be in strict compliance with the manufacturer's printed instructions.

K. All non-complying components and joint systems installed without approved Shop Drawing submittals shall be removed by the Contractor without additional expense to the Owner and shall be promptly replaced with approved components and joining methods for a complete system.

2.11 TDC AND TDF JOINT SYSTEMS: Duct joint connection methods classified as TDC or TDF (all are non-proprietary joints) shall be permitted provided the proposed duct construction meets duct pressure and leakage requirements specified herein. Contractor shall submit test results including air leakage date to the Engineer for review and pre-approval.

2.12 SPLITTER, BUTTERFLY AND MULTI-BLADE DAMPERS shall be in accordance with SMACNA duct construction standards for the specified pressure-velocity classifications.

2.13 MANUAL VOLUME DAMPERS

A. General: Refer to Section 23 31 15 - Ductwork Schedule for ductwork materials of construction for each HVAC system. For all systems, the materials of construction for the damper assembly shall match the materials of construction for the ductwork system in which it is to be installed. All damper assembly components and hardware, including frames, exposed to the airstream shall be alike in kind to the ductwork material and suitable for the intended application. For example, provide all stainless steel damper assemblies in stainless steel ductwork. Damper material gauges and construction features for aluminum or stainless steel dampers shall be

equivalent in strength and function to the Specifications in this Section concerning galvanized steel dampers.

B. Rectangular Dampers:

1. Manual rectangular dampers shall be constructed of minimum 16 gauge mill finish galvanized steel frames and blades with linkage out of the air stream. Dampers shall be opposed blade type and, unless noted otherwise, shall be furnished without blade edge seals. Blades shall be 6" wide, secured to nominal 1/2" diameter shafts. Bearings shall be molded synthetic type bearings or the equivalent. Furnish all manual dampers with a matching heavy duty hand quadrant with minimum 1-1/2" clearance for duct insulation systems. Manual dampers shall be Safe-Air Model 610, Ruskin Model CD35, or approved equal for duct velocities up to 1800 fpm. Where duct velocity exceeds 1800 fpm, provide manual dampers equal to Ruskin Model CD50 or CD60.

2. Manual dampers for duct sizes up to 180 square inches or smaller may be single blade type construction of 22 gauge galvanized steel frame and blade. Damper shall be Ruskin Model MD25 or approved equal. Furnish with integral locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems.

C. Round Dampers: Manual round dampers shall be constructed of minimum 20 gauge mill finish galvanized steel frames and blades with linkage out of the air stream. Dampers shall be single blade type and, unless noted otherwise, shall be furnished without blade edge seals. Control shaft shall be nominal 3/8" square axle shaft that extends beyond the frame to a factory mounted (or field supplied) heavy duty locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems. Manual dampers shall be Ruskin Model MDRS25, Safe-Air Model 613R, or approved equal.

D. Shop Fabricated Dampers (Rectangular or Round): In lieu of manufactured manual volume control dampers, the Contractor may construct shop fabricated damper assemblies in accordance with SMACNA HVAC Duct Construction Standards. Prior to fabrication, the Contractor shall submit shop drawings to the Engineer for approval. Shop Drawings shall indicate frame construction, blade construction, shaft type and size, shaft extension beyond duct wall, maximum and minimum sizes for each type of construction, material gauges, finishes, bearing assemblies, reinforcement, and the like. Furnish with integral locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems.

2.14 CONTROL DAMPERS

A. Control dampers for HVAC systems shall be provided to allow effective modulation or close-off of air flow as required for each fan system. Damper frames shall be constructed to facilitate field assembly of several individual sections into larger damper area and shall be provided with openings or mounting clips to allow secure fastening of damper frame to the surrounding ductwork, collar, or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided with suitable bearings for smooth operation and all blades shall be interconnected to provide unison operation.

B. Dampers shall be provided with either parallel or opposed blade linkage and arranged for normally-open or normally-closed operation as shown on the Drawings. Multi-section dampers shall be provided with sufficient interconnecting hardware and jackshafts to provide unison operation of all blades in the entire assembly.

C. Low Leakage Control Dampers:

1. Frames shall be 5" x 1" x 16 gage galvanized steel channel. Dampers 12" high and less shall be equipped with low profile (5" x 1/2") frame dimensions.

2. Blades shall be 6" wide galvanized steel airfoil shape.

3. Axles shall be 1/2" plated steel hex for positive connection with blades.

4. Bearings shall be non-corrosive two-piece molded synthetic.

5. Blade seals shall be extruded vinyl double edge design with inflatable pocket which enables air pressure from either direction to assist in blade to blade seal off. Blade seals shall be locked in blade slots without the use of cement.

6. Jamb seals shall be stainless steel flexible metal compression type.

7. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

8. Dampers shall be rated for temperatures from -50°F to 250°F.

9. Leakage rate shall be tested and rated in accordance with the Air Movement and Controls Association (AMCA) Standard 500 to have leakage ratings as listed below or better:

Damper Width	Maximum System Pressure	Maximum System Velocity	Leakage % of Max. Flow	Leakage CFM/ Sq. Ft.
48"	6.2 in. wg.	4000 fpm	0.067	2.7
36"	8.5 in. wg.	4000 fpm	0.075	3.0
24"	10.75 in. wg.	5000 fpm	0.060	3.0
12"	13.0 in. wg.	6000 fpm	0.050	3.0

10. Dampers shall be Model CD60 low leakage airfoil control dampers as manufactured by Ruskin, Arrow, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Johnson Controls, and Safe-Air.

2.15 INSTRUMENT PORTS shall be Duro Dyne Air Tight Instrument Test Port with neoprene expansion plug for instruments up to 1-1/32 and flat neoprene mounting gasket, or equal. Ports shall be air tight with heavy duty die cast construction, zinc plated heavy gauge cap and instant release wing nut.

2.16 ACCESS DOOR LATCH shall be Ventfabrics, Inc. No. 260 "Ventlock", or equal latch for

doors large enough to enter only.

2.17 QUADRANTS, CONTROLS, INDICATING INSTRUMENTS and similar equipment shall be provided with extensions and/or brackets for mounting on the surface of the insulation of externally insulated ducts.

2.18 SUPPORT AND BRACING MATERIAL for galvanized ductwork shall be galvanized steel. Dielectrically isolate galvanized steel supports from aluminum duct with two coats of zinc-chromate paint or bitumastic paint. Support and bracing material for stainless steel ductwork shall be stainless steel.

2.19 FLEXIBLE CONNECTIONS

A. Large Flexible Connections (Greater than 8 feet total duct perimeter):

1. Connections shall be made with Duro Dyne Type "Super Metal Fab" wide span fabric or equal.

2. Fabric shall be 6" wide Excelon type by Duro Dyne. Fabric shall be of tear resistant construction with a no-tear nylon base cloth. Fabric shall be suitable for outdoor use where required. Weight of fabric shall be approximately 22 oz. per sq. yd.

3. Integral metal connector pieces shall be nominal 3" wide, 24 gauge, metal "Grip-Loc" seam or equal.

4. Fabric and fabric assembly shall be UL listed and NFPA 90A approved.

B. Flexible Connections (Smaller than 8 feet total duct perimeter):

1. Connections shall be made with Duro Dyne Type "Metal Fab" fabric or equal.

2. Fabric shall be 3" wide Neoprene type by Duro Dyne. Fabric shall be of durable construction consisting of a heavy glass fabric double coated with Neoprene. Weight of fabric shall be approximately 30 oz. per sq. yd.

3. Integral metal connector pieces shall be nominal 3" wide, 24 gauge, metal "Grip-Loc" seam or equal.

4. Fabric and fabric assembly shall be UL listed and NFPA 90A approved.

2.20 DUCT SLEEVES through floors shall be at least 14 gage galvanized steel.

2.21 RECTANGULAR FIRE DAMPERS shall be as follows:

A. Duct mounted dampers shall be factory built curtain type, with blades out of airstream (Type B). Dampers installed at sidewall registers or grilles shall be factory built curtain type, with blades in the airstream (Type A).

B. Dampers located in aluminum or stainless steel ductwork shall be constructed entirely of 304 stainless steel.

C. Dampers shall have a minimum 1-1/2 hour fire protection rating and shall include a U.L. label in accordance with UL555 standard.

D. Dampers shall have a dynamic label that shall illustrate maximum allowed CFM at 8" static pressure for in-duct mounting and maximum allowed CFM at 4" static pressure for non-ducted, in-wall mounting.

E. Dampers shall have vertical and horizontal closure spring operation for assured closure under airflow.

F. Provide factory built sleeves of design and length to permit mounting within the opening, and as required to meet local code requirements.

G. Factory manufactured fire dampers shall be by Ruskin, Prefco Products, Louvers and Dampers, Inc., or approved equal.

H. Fusible links shall be temperature rated in accordance with NFPA 90A.

I. Each fire damper type and rating shall be as required to maintain the fire resistive construction rating of the floor, wall or partition in which it is installed.

J. See Drawings for additional information and requirements.

2.22 ROUND FIRE DAMPERS

A. Duct mounted fire dampers in round ducts shall be round type with butterfly damper and linkage with fusible link located within the air stream.

B. Dampers located in galvanized duct systems shall be galvanized steel construction. Dampers located in aluminum or stainless steel duct systems shall be constructed entirely of 304 stainless steel.

C. Dampers shall have a minimum 1-1/2 hour fire protection rating and shall include a UL label in accordance with UL 555 Standard.

D. Dampers shall have a dynamic label that shall illustrate maximum allowed CFM at 8” static pressure for in-duct mounting and maximum allowed CFM at 4” static pressure for non-ducted, in-wall mounting.

E. Provide factory built retaining plates of design and length to permit mounting within the opening and as required to meet local code requirements.

F. Factory manufactured fire dampers shall be Ruskin Model FDR25 or approved equal by Prefco Products, or Louvers and Dampers, Inc.

G. Fusible links shall be temperature rated in accordance with NFPA 90A.

H. Each fire damper type and rating shall be as required to maintain the fire resistive construction rating of the floor, wall or partition in which it is installed.

I. See Drawings for additional information and requirements.

2.23 COMBINATION FIRE AND SMOKE DAMPERS

A. Combination fire and smoke dampers and actuators shall be rated for 2000 fpm at 4" w.g. and elevated temperature of 250°F. Dampers shall have a UL555 fire rating of 1 ½ hours and shall meet the requirements of UL555S Leakage Class 2.

B. Frames shall be 5" x 16 gage galvanized steel channel.

C. Blades shall be one piece airfoil, 6" wide, 16 gauge minimum galvanized steel.

D. Axles shall be 1/2" minimum plated steel with stainless steel bearings pressed into frame

E. Blade seals shall be silicone edge type mechanically fastened to blades and rated for up to 450 deg, F. Galvanized steel seals shall provide flame seal to 1900°F.

F. Jamb seals shall be stainless steel flexible metal compression type.

G. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

H. Dampers and controls shall be as scheduled on the drawings and shall be manufactured by Ruskin, Arrow, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Johnson Controls, and Safe-Air.

2.24 FIRESTOP SEALS: All holes, voids, or openings created to extend mechanical systems through fire rated floors, partitions and walls shall be sealed by the Contractor with an intumescent material capable of expanding up to 10 times when exposed to temperatures beginning at 250°F. It shall be UL Classified and have ICBO, BOCAI, and SBCCI (NER 243) approved ratings to 4 hours per ASTM E-814 (UL 1479). Manufacturers shall be 3M, or equal by Dow Corning.

2.25 RADIATION DAMPERS

A. Where not supplied as an integral diffuser, damper, and blanket assembly; ceiling fire damper assemblies shall be provided to maintain rated Floor/Ceiling assemblies.

B. Dampers shall be U.L. listed for rated assemblies and sized per opening.

C. Dampers and accessories shall be Ruskin, Prefco Products, or approved equal.

2.26 ACCESS DOORS

A. Access doors shall have minimum 22 gauge frames and 24 gauge door panels. Materials of construction for the access door and all hardware shall match the duct system materials of construction.

B. Doors shall have continuous hinge assemblies.

C. Latches shall be sash type with matching strikes.

D. Doors shall be double wall construction with 1" thick enclosed fiberglass insulation.

E. Gaskets shall be PVC foam type or neoprene, and comply with the requirements of NFPA 90A for flame spread and smoke developed ratings.

F. If space does not permit door opening, removable door models may be used.

G. Access doors for round ductwork shall be of the rolled hinge plate design shaped to match the contour of the duct or bolted access door design with integral hand operated knobs to create a compression fit with the duct wall. Bolted type round duct access doors shall be Sandwich type by Ductmate Industries, or equal, and shall comply with the requirements of the general paragraphs above relating to access door construction.

H. Rectangular access doors for rectangular ductwork shall be Cesco Model HAD or CAD, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Safe-Air, and Ruskin. Round access doors for rectangular ductwork shall be Flexmaster "Inspector Series" access doors, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Safe-Air, and Ruskin.

2.27 MOISTURE DRAIN: Provide where shown on plans. Duct mounted moisture drains shall be Ductmate Industries Moisture Drain, or approved equal. The drain connection shall be accomplished by drawing a portion of the duct wall into a funnel shape. The base of the moisture drain shall be 12 gauge galvanized steel to resist deformation. The drain shall consist of a chrome-plated brass threaded drain, nut, and cap. The drain installation shall provide a leakproof connection. Minimum size of drain shall be 3/4".

2.28 PLENUM WALL CONSTRUCTION

A. Plenum wall panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets. Plated fasteners will not be accepted.

B. All panels shall be double wall smooth mill finish aluminum construction with minimum 0.040" aluminum exterior and interior skin thickness. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

C. The minimum panel thickness shall be 2" thick with polyisocyanurate foam insulation. Panel shall comply with NFPA 90A requirements.

D. Casing design static pressure shall be at 6" w.g. positive and 6" w.g. negative. Thickness of the panel skin, core density, rib structural frame spacing shall be regulated to eliminate panel pulsation and restrict the maximum deflection to 1/200 of any span at design load of 1-1/2 times the design positive or negative pressure. Casings shall be built to exceed AMCA Class "C" requirements.

E. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no more than 1% of the design volume at the design operating pressure or 30 CFM, whichever is greater.

F. Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.

G. Any equipment flashing shall be made in such a way to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.

H. All ductwork and air handling unit connections shall be made with flanged connections of same material as the wall panel. Pipe and conduit penetrations through panels shall be properly sealed with gaskets. Penetrations sealed by simply caulking around extension are not acceptable.

I. Access doors shall be of the same construction as panels described above. Provide automotive style neoprene gasketing around full perimeter of access doors to prevent air leakage. Provide "ventlock" style non-corrosive alloy latches operable from the inside or outside of unit. Provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

J. Each access door shall be provided with minimum 10” square, thermopane safety glass window.

K. Each access door shall be mounted with a corrosion-resistant stainless steel continuous piano hinge.

L. Removable access panels shall be provided as required for service and maintenance. Access panels shall be of the same construction as the panels. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels. Airtight integrity must be maintained.

2.29 INSULATED FLEXIBLE DUCTWORK

A. Low pressure flexible duct shall be a factory fabricated assembly of a trilaminate of reinforced aluminum foil vapor barrier, fiberglass insulation, and CPE inner film with high tear strength, and properties to resist temperature change, mildew, and age hardening.

B. The liner shall be mechanically locked, without adhesives, into a corrosive resistant galvanized steel helix formed on the ducts outside surface.

C. The duct shall be a U.L. listed 181 Class 1 duct material and shall comply with NFPA 90A and 90B.

D. The material shall have a positive pressure rating of not less than 6” w.c. through a temperature range of –20 to 250ºF.

E. The duct material shall be factory wrapped in a thick blanket of fiberglass

insulation with a C factor of 0.23 or less.

F. The insulation shall be encased in a fire retardent reinforced aluminum material vapor retarder with a perm rate of not over 0.05.

G. The duct shall be rated for 4000 fpm duct velocity.

H. Provide adjustable diameter type self-locking nylon clamps as manufactured by Panduit, or equal.

I. Flexible duct shall be Type 8M as manufactured by Flexmaster or equal by Thermaflex.

J. Take-offs for flexible ductwork shall be made using Flexmaster Model SRO (or approved equal) rectangular to round side take-offs with integral balancing damper. Damper shall be provided with locking quadrant handle, and insulation standoff.

2.30 SOUND ATTENUATORS

A. Sound attenuators shall be Ruskin Type AM or Engineer approved equal. Attenuators shall be factory assembled, broad band rectangular type, with 8 inches w.g. operating pressure, 18 gauge G90 galvanized steel outer casing, 22 gauge G90 perforated galvanized steel internal liner, and glass fiber fill acoustic material, with mylar liner.

B. Acoustical performance shall meet or exceed schedule values in accordance with ASTM E477 testing procedure.

C. Static pressure loss shall not exceed scheduled values.

2.31 DUCTWORK ACOUSTICAL LAGGING

A. Acoustic lagging shall be moisture resistant gypsum wall board completely covering top, bottom and sides of ductwork. Lagging shall be attached with galvanized sheet metal screws on 8″ centers each way. Edges and seams shall be overlapped a minimum of 4″. Joints at access doors, walls, and other locations shall be tightly butted and sealed with canvas and vapor retardant mastic.

B. Acoustical lagging thickness shall be two layers of ½″ thick moisture resistant gypsum wall board with staggered joints.

C. Hangers for ducts with acoustical lagging shall be sized for the intended load and spaced at not greater than 5 ft between each hanger.

2.32 VIBRATION ISOLATION HANGERS

A. Spring Hangers: Spring hanger shall be Mason industries type 30 with 1″ deflection and neoprene bridge bearing or equal by VMC or B Line.

B. Neoprene Vibration Isolation Hangers: Hangers shall be Mason Industries Type HD or equal by VMC or B Line.

PART 3 - EXECUTION

3.1 DUCTWORK

A. All ductwork, hangers, and supports shall be fabricated and installed in accordance with applicable SMACNA Standards according to the pressure class described in PART 1 - GENERAL.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

C. Ductwork shall be supported as recommended by SMACNA Standards from structural members. Ductwork shall not be allowed to rest on ceiling, light fixtures or structural members. Ductwork supported from joists shall be supported from the top chord of joists.

D. Ducts, unless otherwise approved, shall be true to dimensions indicated, straight and smooth on inside with neatly finished joints, securely anchored to building in an approved manner, and installed to be completely free from vibration or chatter under all conditions of operation. Exact routing of ductwork will be dependent on location of structural members, and coordination with locations of other utilities. Route duct to avoid cutting structural members.

E. Brace ducts not more than 60 inches on center. Make slip joints in direction of flow, unless shown otherwise on the Drawings. Off-set ducts around obstructions where possible. The total included angle of duct tapers or transitions shall not exceed 45^{o} for diverging air flow or 60^{o} for converging air flow. However, in no case shall the angle between the air flow path entering the transition, and any side of the transition, exceed 30^{o} for diverging or converging air flow. In general, diverging transitions shall be limited to 15^{o} from the air flow path, and the above angles shall be considered maximum requirements.

F. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent of duct area, split into two ducts, maintaining original duct area.

G. Use double nut and lock washers on threaded rod supports.

H. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

I. Provide dielectric isolation between aluminum ductwork and steel materials at ductwork joints and supports. Isolation may be provided with two coats of zinc-chromate paint or bitumastic paint. Ensure that there is no metal to metal contact.

J. All ductwork accessories shall be installed in strict accordance with manufacturer's recommendations.

3.2 SPECIAL ITEMS OF EQUIPMENT: Install special items of equipment in the duct

systems, including automatic dampers, thermostats, humidistats, thermometers and other related controls, under the direct supervision of the Controls Contractor. Install fire alarm system smoke and temperature sensors under the direct supervision of the Electrical Contractor.

3.3 QUADRANTS, CONTROLS, INDICATING INSTRUMENTS: Mount quadrants, controls, indicating instruments and similar equipment on the surface of the insulation of insulated ductwork.

3.4 ENLARGE DUCTS designated to be lined by an amount equal to the lining thickness, so as to maintain the indicated air flow dimensions. Duct lining shall be in accordance with Section 23 07 00 - Insulation.

3.5 CROSS BREAK OR BEAD DUCTWORK having a width or depth in excess of 12 inches.

3.6 VOLUME CONTROL: Provide volume control and balancing dampers of the splitter, butterfly or multi-louver type for controlling air volume and direction and for balancing the system. Stiffen ducts at damper locations to provide adequate rigidity. Provide balancing damper for each supply diffuser or grille where branch duct connects to supply duct.

3.7 ACCESS DOORS: Provide access doors in duct for all automatic dampers, fire dampers, controls, filters and similar equipment.

3.8 INSTRUMENT PORTS: Provide instrument ports in ductwork for pitot tube test where required for air flow measurement. Coordinate with TAB Contractor.

3.9 FLEXIBLE CONNECTIONS: Seal flexible connections and firmly band at each connection point. Flexible connections shall be not less than 4 inches in length.

3.10 DUCT SEALING: Sealing shall be done as required in Part 1 - General in this section, using duct sealer, duct sealer and tape, or gaskets in accordance with SMACNA duct construction standards, manufacturer's recommendations, and this Specification.

3.11 SLEEVES THROUGH FLOORS

A. Provide sleeves through floors for all ducts passing through floors, except where ducts are enclosed in a sealed chase. Sleeve shall extend 2 inches above finished floor and shall be secured permanently in place.

B. Construct watertight joint between sleeve and floor with sufficient reinforcing to assure permanent watertightness.

C. Provide cover at the bottom of the sleeve and pack space between sleeve and duct with fiberglass insulation.

D. Where fire dampers are required, omit the sleeves but make the joint between the fire damper collar and the floor watertight.

3.12 FIRE DAMPERS

A. Fire dampers shall be installed at all locations where ductwork penetrates any floor, wall or partition with a fire rating of 2 hours or more, and where

otherwise shown or specified on the Drawings.

B. Fire dampers shall be installed at all locations where ductwork penetrates walls or partitions with a 1 hour fire rating. Fire dampers may be omitted where fire dampers are not shown on plans provided the sheet metal duct is 100 square inches or less, does not communicate the corridor with adjacent spaces, is installed above a ceiling, and does not terminate at a wall register in the fire rated wall.

C. Install fire dampers in accordance with manufacturer's UL approved printed instructions, or SMACNA's Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, whichever is more stringent.

D. Provide and locate access door to allow easy adjusting and link replacement.

E. Adjust fire dampers as follows:

1. Disconnect fusible link.

2. Operate the fire damper several times.

3. Adjust and correct each fire damper to assure free, positive operation and proper latching.

4. Reconnect fusible link.

3.13 FIRESTOP SEALS shall be installed in strict accordance with the manufacturer's recommendations for each type of opening or void. Surfaces shall be smooth and without gouges or other irregularities.

3.14 DUCT SMOKE DETECTORS shall be furnished by the Electrical Contractor under Division 16 and installed in the duct system by the Mechanical Contractor. All wiring and interlocks shall be furnished and installed by the Electrical Contractor.

3.15 CLEANING

A. All ductwork shall be thoroughly cleaned inside and out prior to system startup, and shall be left in a neat and orderly manner. Duct sections, open ends, taps, and the like shall be covered with plastic at <u>all</u> times during construction to prevent entry of dust and debris.

B. See Section 23 00 10 - Mechanical General Provisions, and Section 23 05 93 - Tests, for additional requirements.

3.16 STARTUP, TESTING, ADJUSTING & BALANCING: See Sections 23 00 10 - Mechanical General Provisions, and 23 05 93 – Testing, Adjusting and Balancing for HVAC.

END OF SECTION

SECTION 23 31 15
DUCTWORK SCHEDULE - SERVICE & MATERIAL SYSTEM

A. GENERAL NOTES & LEGENDS:

1. Refer to Section 23 3113 - Ductwork, and Section 23 0700 - Insulation, for detailed material and installation requirements. Refer to Section 23 3113 for insulated flexible ductwork. Note: Not all materials described in Part A of this Specification are used on this project. Refer to attached schedules for required material applications.

2. Ductwork & Hanger Material Legend: (See Section 23 3113 - Ductwork)

System	Description
AL	Aluminum
BS	Black Steel
GN	Galvaneal Steel ("PAINTGRIP")
GS	Galvanized Steel
SC	Black Steel with Steelcote S.S. Filled Urethane Finish
SS	Stainless Steel (304)

3. Material Schedule - Ductwork Insulation: (See Section 23 0700 - Insulation)

System	Description
A	Molded glass fiber
B	Rigid glass fiber
C	Flexible glass fiber - 0.75 lb/cu. ft. ductwrap
D	Glass fiber duct liner - 1.5 lb/cu. ft.
E	Glass fiber duct liner - 3.0 lb/cu. ft.
F	Foamed plastic without finish
G	Foamed plastic with 2-coat finish
H	Phenolic foam
J	Engineered Polymer Foam Duct Liner (FPFI)

4. Jacket Material Legend: (See Section 23 0700 - Insulation)

System	Description
A	Foil-Scrim-Kraft
B	Canvas - field applied
C	Fiberglass - field applied
D	PVC sheet - field applied, solvent weld
E	Aluminum sheet - field applied
F	Stainless Steel - field applied

5. Insulation Thickness Legend:

050	=	1/2" Thick
075	=	3/4" Thick
100	=	1" Thick
150	=	1-1/2" Thick
200	=	2" Thick
250	=	2-1/2" Thick
300	=	3" Thick

B. SERVICE & MATERIAL SYSTEMS: See the following DUCTWORK SCHEDULE.

C. SCHEDULE NOTES:

1. See Drawings for detailed requirements.

2. Flexible ductwork shall not be used upstream of VAV terminal units.

3. See specific ductwork and insulation requirements at VAV terminal unit detail on Drawings.

4. Insulate exterior of heating coil and adjacent ductwork per equipment insulation schedule in Section 23 0700.

5. Firestop duct penetration thru wall. Do not extend insulation thru wall.

6. Provide dielectric isolation between aluminum ductwork and steel materials at ductwork joints and supports. Isolation may be provided with two coats of zinc-chromate paint or bitumastic paint. Ensure that there is no metal to metal contact.

7. Supply and return ducts located in unconditioned spaces shall be insulated with a minimum of R-5 insulation in accordance with 2012 NC Energy Code.

8. Supply and return ducts located outside of the building shall be insulated with a minimum of R-8 insulation in accordance with 2012 Energy Code.

SECTION 23 31 15 - DUCTWORK SCHEDULE - SERVICE & MATERIAL SYSTEMS

DUCTWORK SYSTEM: DUCTWORK LOCATION:		DOAS	VRF UNITS			
Supply Air	Temperature Range	50°F-100°F	50°F-100°F	-	-	-
	Ductwork Material	GS	GS	-	-	-
	Hanger Materials	GS	GS	-	-	-
	Insulation	100C	200C	-	-	-
	Jacket	A	A	-	-	-
	Pressure Class (in.)	2.0	1.0	-	-	-
	Seal Class	A	A	-	-	-
Return Air/ Exhaust	Temperature Range	50°F-100°F	55°F-85°F	-	-	-
	Ductwork Material	GS	GS	-	-	-
	Hanger Materials	GS	GS	-	-	-
	Insulation	-	200C	-	-	-
	Jacket	A	A	-	-	-
	Pressure Class (in.)	2.0	1.0	-	-	-
	Seal Class	A	A	-	-	-
Outside Air	Temperature Range	-	-	-	-	-
	Ductwork Material	-	-	-	-	-
	Hanger Materials	-	-	-	-	-
	Insulation	-	-	-	-	-
	Jacket	-	-	-	-	-
	Pressure Class (in.)	-	-	-	-	-
	Seal Class	-	-	-	-	-
Relief Air	Temperature Range	-	-	-	-	-
	Ductwork Material	-	-	-	-	-
	Hanger Materials	-	-	-	-	-
	Insulation	-	-	-	-	-
	Jacket	-	-	-	-	-
	Pressure Class (in.)	-	-	-	-	-
	Seal Class	-	-	-	-	-

*Low pressure supply ductwork, downstream of VAV boxes, may be constructed for 1” Pressure Class.

END OF SECTION 23 31 15

SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 DEFINITIONS:

A. Diffusers are ceiling mounted air supply outlets with built-in volume and flow direction adjustments. Diffusers are intended to rapidly mix supply air with room air.

B. Linear diffusers have one or more long slot-type air supply outlets with built-in volume and flow direction adjustments. Linear diffusers may be ceiling, wall or floor mounted.

C. Supply grilles and registers are ceiling, wall or floor mounted air supply outlets with adjustable vertical and/or horizontal air direction vanes. Vertical vanes shall be on the room side of wall mounted units.

D. Return grilles and registers are ceiling, wall or floor mounted air return or transfer inlets with fixed vertical and/or horizontal vanes. Vertical vanes shall be on the room side of wall mounted units.

E. Registers have built-in volume adjusting opposed-blade dampers, whereas grilles do not.

F. High capacity industrial grilles are wall or ceiling mounted air supply outlets offering directional control of large air volumes.

1.3 CEILING DIFFUSERS, GRILLES AND REGISTERS shall be as scheduled on Drawings.

1.4 ADJUSTABLE AIR EXTRACTORS shall be provided behind supply grilles and at branch ducts where shown on the Drawings and scheduled on the air distribution schedules.

1.5 SOUND PRESSURE LEVEL of all diffusers, grilles and registers shall not exceed NC 30 (unless otherwise scheduled) in all areas, at the scheduled maximum air flow. NC ratings are based on sound power level re 10^{-12} watts minus an 8 db room attenuation in all octave bands.

1.6 SHIPPING TAG: Each unit shall be tagged at the factory with its specific location on the job, including building floor, room/area served, and the unit designation shown on the Drawings.

1.7 SUBMITTALS: Submit the following for each air distribution device:

A. Manufacturers details indicating components, dimensions, connections, clearances.

B. Performance criteria indicating type, size, total static pressure, cfm, NC rating, neck size, and throw pattern on each individual device.

C. Materials of construction.

D. Finishes.

E. Accessories and options.

F. Installation details and mounting methods.

G. Reference to the Contract Documents for performance information is unacceptable.

1.10 SAMPLES: Submit samples of diffusers, grills and registers at the request of the Engineer for approval.

PART 2 - PRODUCTS

2.1 DIFFUSERS, GRILLES, REGISTERS AND ACCESSORIES shall be the products of Metal*Aire, Carnes, Price, Titus, or Tuttle & Bailey.

2.2 ONE MANUFACTURER'S products shall be used for like components throughout the work. Do not mix manufacturers without the prior written approval of the Owner's representative or unless required to comply with product specifications and performance criteria.

2.3 PRODUCT MODEL NUMBERS, types, sizes, styles, accessories and other details shall be as scheduled on the Drawings.

PART 3 - EXECUTION

3.1 COORDINATE with General Contractor for all openings and penetrations required in building construction for air outlets and inlets, prior to the construction of work to be penetrated.

3.2 SURFACE MOUNTED OUTLETS AND INLETS: Fit surface mounted outlets and inlets tight against the surface on which they are mounted with no perceivable gaps between the outlet or inlet and the mounting surface and gasket of the grille, register, or diffuser.

3.3 INSTALL OUTLETS AND INLETS level and plumb with building surfaces. Fasten securely to the adjacent structure or surface as recommended by the manufacturer with matching tamper-proof fasteners.

3.4 INSTALL EXTRACTORS behind grilles with adjustment rods and locking screws so extracted air volume can be adjusted by removal of grilles.

3.5 INSTALL EXTRACTORS at branch ducts with adjustment rods extending through duct wall and insulation to setscrew collar.

3.6 PROVIDE T-bar panels as required to match standard lay-in ceiling modules.

3.7 INSTALL minimum 1-1/2" thick fiberglass blanket insulation with vapor retarder jacket

securely taped to the backside (plenum side) of all supply diffusers installed in lay-in ceiling assemblies to prohibit the formation of condensate on the diffuser face.

3.8 INSTALL fire dampers behind sidewall grilles installed in rated walls. Refer to Drawings and Air Distribution Schedule.

3.9 PROVIDE ceiling radiation dampers for inlets and outlets as scheduled on the Drawings.

END OF SECTION

SECTION 23 62 46
VARIABLE REFRIGERANT FLOW UNITS

PART 1 – GENERAL

1.1 SYSTEM DESCRIPTION

A. The outdoor unit shall consist of one or more frames connected through common refrigerant piping and control communication wiring. Each system shall have single or multiple, inverter compressor(s). Each system shall be connected to multiple indoor units (ducted, non-ducted or mixed combinations) through a common refrigerant piping network and integrated system controls and communication network. Each indoor unit shall be controlled individually or as a group. Additionally, heat recovery systems shall be capable of simultaneous heating and cooling of individual zone(s).

B. Simultaneous heating/cooling (heat recovery) systems shall consist of an outdoor unit, BC (Branch Circuit) Controller (or comparable branch devices), multiple indoor units, and an integral DDC (Direct Digital Controls) system. Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units or groups. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. To ensure owner comfort, each indoor unit or group of indoor units shall be independently controlled and capable of changing mode automatically when zone temperature strays 1.8 degrees F from set point for ten minutes.

C. The VRF manufacturer shall provide published outdoor unit performance data in table format which states the products heating and cooling capacity expressed in British thermal units per hour (Btuh) and power consumption expressed in kilowatts (kW) at a minimum of 8 possible combinations of allowed conditions between 50% and 130% connection ratio. Possible combinations of allowed condition variables include Combination Ratios expressed as a percentage value, Outdoor Ambient Temperature expressed in degrees Fahrenheit (°F), and indoor unit Entering Air wet and dry bulb temperature expressed in degrees Fahrenheit (°F). Any product whose system design and engineering manuals or guides where published data tables are expressed in units other than these specified will not be accepted.

1.2 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.

B. All wiring shall be in accordance with the National Electric Code (NEC).

C. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

D. Mechanical equipment for wind-born debris regions shall be designed in accordance with ASCE 7-2002 and installed to resist the wind pressures on the equipment and the supports.

E. The condensing unit will be factory charged with R410A.

1.3 SUBMITTALS

A. A complete submittal package shall be compiled and forwarded to the general contractor who shall supply the architect with the submittals for dissemination to all parties. The submittal shall be a collection of documents that represent the technical aspects of each product or collection of products to be used on the project. All performance submissions shall be calculated at the design temperatures; nominal performance data shall not be allowed. The submission and approval of said submittals does not relieve the contractor of supplying all requirements set forth in the specification and drawings. Any substitutions offered by the contractor shall include, as a separate document, any and all differences between the submitted products and the specified products including but not limited to, all dimensions, electrical, control, weights, warranties, country of origin and a statement from the manufacture that no child labor has been used in the manufacture or assembly of said products and a copy shall be supplied with the product outdoor unit submittal.

B. If submittals contain any proposed alternate equipment specifications, calculations, dimensions, electrical specifications, sound specifications or any other mandated submission which are not accepted, are noted or rejected for any reason the contractor shall be allowed to correct any deficiency and re-submit a second time. Should there be any issues found on second submission the contractor will be directed to and agrees to submit on the original specified products and provide the specified products without any additional compensation.

C. Upon job completion: Provide the owner with a copy of approved submittal, VRF system service diagnostics software, project mechanical and control drawings, all as-built piping drawings, O&M's, troubleshooting guides, service manuals and engineering manuals in PDF format.

1.4 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer's recommendations.

PART 2 – WARRANTY

2.1 LIMITED WARRANTY

Manufacturer shall warrant products (the "Products") will be free from defects in material or workmanship. This warranty applies to parts only and is limited in duration to one (1) year from the date of original installation.

2.3 EXTENDED WARRANTY

For compressors only, the manufacturer shall provide the above warranty (which is applicable to parts only) for a five (5) year period. This extended warranty for

compressors is limited in duration to five (5) years from the date of original installation, and applies to the compressor and compressor parts only.

2.3 INSTALLATION REQUIREMENTS

The system must be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents.

PART 3 – PERFORMANCE

3.1 DESIGN BASIS

A. VRF systems shall be Daikin, Mitsubishi or Hitachi. All bidders shall furnish the minimum system standards as defined by the base bid model numbers, model families or as otherwise specified herein. The contractor shall be responsible for all specified items and intents of this document without further compensation.

PART 4 – PRODUCTS

4.1 CONDENSING UNIT

VRF Heat Pump Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.

A. Cooling: 14°F DB to 122°F DB
B. Heating: -13°F WB to 61°F WB
C. Cooling based synchronous: 14°F DB to 81°F DB
D. Heating-based synchronous: 14°F WB to 61°F WB

General features:

A. The air-conditioning system shall use R410A refrigerant.
B. The system shall be capable of an automatic refrigerant charge function for use in both the heat mode and cool mode to ensure the proper amount of refrigerant is installed into the system.
C. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
D. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
E. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
F. Refrigerant circuit configuration for Heat Recovery System
   (i) The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, piped together with manufacturer supplied Heat Recovery unit(s) and Y- branches connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the simultaneous heating and cooling operation of the VRF system. Other pipe materials shall not be allowed.
G. Each refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less

than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

(ii) All joints shall be glued and sealed per insulation manufactures instructions to make an air tight assembly.

H. Factory installed microprocessor controls in the outdoor unit(s), HR unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and HR unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.

I. Inverter PCB cooling: cooling of the inverter PCB shall be conducted by way of passive heat transfer via "Heat Pipe" technology and/ or highly conductive sink method to the outdoor ambient for dissipation to the ambient via natural convection and also by way of forced convection when the outdoor condenser fans are running. Additional cooling of the inverter PCB using mechanical devices other than an existing condenser fans shall not be allowed. Further, use of outdoor coil space or sections to cool inverter PCB shall not be permitted.

J. Compressor control: Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance.

K. Flexible Capacity Control: (Demand limiting) The system shall allow for up to 5 steps of flexible capacity control using an I/O controller or up to 8 steps of flexible capacity control using a BMS control by others. This FCC shall be employed when electrical demand limiting, night time noise reduction or any other flexible capacity control requirement based on any other requirement using contact closures to engage.

L. Initial Test Run (ITR) (Heating) / Fault Detection Diagnosis (FDD) Code: this control mode shall monitor and display positive or negative results of system initial startup and commissioning. It shall monitor the following but not limited to refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, number of indoor units connected. This control mode shall not replace the system error monitoring control system.

M. Integration Each system shall be able to integrate via open protocol via BACnet IP.

N. Smart load control: Smart load control operation shall be available at any time during or after system commissioning.

O. Smart load control shall be initiated by outdoor air temperature and shall automatically adjust the evaporator target (condenser target for heat) pressure / temperature that the system will operate to in order precisely load match the system to the building load as the outdoor ambient increases or decreases, by varying the compression ratios of the system and increase the operating efficiencies by adjusting the compressor lifts.

The system shall poll all indoor units' data in real time and apply its algorithm to determine the optimal evaporating temperature to satisfy varying loads. Systems that rely on the worst performing zone to reset the system conditions shall not be sufficient and shall not be allowed.

P. WiFi communication: The outdoor unit shall be WiFi enabled and capable. WiFi shall allow service or maintenance personal access to the complete operating system without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or Collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc. by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

Q. Indoor unit connectivity: The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

R. Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

S. Connection Ratios: The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50% and no more than 130% of outdoor unit's nominal capacity.

T. The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

U. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, contacts, relay(s), fans, power and communications wiring as necessary.

V. Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
    1. Refrigerant strainer(s)
    2. Check valve(s)
    3. Inverter driven, medium pressure vapor injection, high pressure shell compressors
    4. Heat pipe cooled inverter PCB
    5. Oil separator(s)
    6. Accumulator(s)
    7. 4-way reversing valve(s)
    8. Vapor injection valve(s)
    9. Variable path heat exchanger control valve(s)
    10. Oil balancing control
    11. Oil Level sensor(s)
    12. Electronic expansion valve(s)
    13. Sub-cooler (s)
    14. High and low side Schrader valve service ports with caps.
    15. Service valves

Refrigerant Flow Control

A. System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency of the system.
B. System shall have a medium pressure gas vapor injection function employed in the heating mode to increase system capacity when the outdoor ambient temperatures are low. The compressor vapor injection flow amount shall be controlled by the VI sub-cooling algorithm reset by discharge gas temperatures of the compressor.
C. System shall have an active refrigerant control and multi section accumulator that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system efficiency.
D. The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be same as discharge pressure. The motor shall be cooled by high pressure gas and as a result oil shall be stable and non-foaming increasing the efficiency of the system.
E. The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a double spiral tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required
F. System shall have following frame configurations vs. capacity.
    i. 6 to 14 ton units shall be a single frame only.
    ii. 16 to 28 ton units shall be dual frame only.
    iii. 30 to 42 ton heat recovery units shall be triple frame only

Field Supplied Refrigerant Piping Design Parameters

A. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.
B. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
C. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
D. The piping system shall be designed with pipe expansion and contraction possibilities in mind. If required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. Piping systems must be installed per manufacturer's published guidelines
E. Pipe hanger and supports selected should allow for expansion and contraction of the piping system shall not interfere with that movement.

Defrost Operations

A. The outdoor unit(s) shall be capable of Intelligent defrost operation to melt accumulated frost, snow and ice that may have accumulated on the outdoor unit heat exchanger. The defrost cycle length and

sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables.

B. Defrost Mode Selection: The outdoor unit shall be provided with three field selectable defrost operation modes; Normal, Fast, or Forced.
   1. *Normal Defrost* operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods to minimize energy consumption and cycle time.
   2. *Fast Defrost* operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is above 32°F, Intelligent Defrost shall continue to heat until the discharge temperature declines. At temperatures below 32°F, the time between defrost cycles shall be a minimum of 90 minutes. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.
   3. *Forced Defrost* operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

C. Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods; Split Coil/Frame and Full System.
   1. Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat Recovery *single-frame* VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat Recovery *multi-frame* outdoor units.
   2. Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for six minutes, then the bottom half for six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.
   3. When Split Coil/Frame method is selected, a Full System defrost shall be occur every third defrost cycle to assure 100% of the frozen precipitation has been removed to maintain efficient performance.
   4. Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall select the Full System defrost method.

D. Indoor Unit Fan Operation During Defrost
   1. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.
   2. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain

normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.

3. During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

Oil Management

A. The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed

B. Each compressor shall be provided with an independent centrifugal oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.

C. The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller.

D. The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor.

E. A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.

F. Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.

G. Indoor Unit Fan Operation During Oil Return Cycle

1. During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.
2. During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.
3. During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes except 4.07.e.1 and 2.

Cabinet

F. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours. The test report results with photo images shall be included with submittal documentation.

G. The front panels of the outdoor units shall be removable type for access to internal components.

H. A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws shall be provided to access the following:

1. Service tool connection
2. DIP switches
3. Auto addressing
4. Error codes
5. Main microprocessor
6. Inverter PCB

I. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.

Fan Assembly

A. 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.
B. 8 to 14 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.
C. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
D. The fan(s) motor shall be equipped with permanently lubricated bearings.
E. The fan motor shall be variable speed with a maximum operating speed of 1050 RPM.
F. The fan shall have a raised guard to help prevent contact with moving parts.
G. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
H. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 in-wg to accommodate ducted installations.
I. The fan control shall have a function setting to remove excess snow automatically.

Outdoor Unit Coil

A. Shall be comprised of aluminum fins mechanically bonded to copper tubing.
B. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
C. The aluminum fins shall have factory applied corrosion resistant GoldFin™ material with a Hydrophilic top coat.
D. Coil coating shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours. The test report results with photo images shall be included with submittal documentation.
E. Shall have multiple circuits designed for path isolation and variable velocity control.
F. Shall be designed, built and provided by the VRF outdoor unit manufacturer
G. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or allow field testing at 550 psig shall not be allowed.
H. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 14 Fins per Inch (FPI). All the outdoor unit coils shall be a minimum of 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger.
I. The cabinet shall have a factory installed coil guard.

Compressor(s)

A. Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.
B. 12 and 14 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.
C. Each inverter driven, HSS scroll compressor shall be capable of operating from 15 Hz up to 150 Hz with control in 0.5 Hz increments in any and all modes (cooling OR heating)
D. Manufacturers that employ speed limiting algorithms designed to limit compressor capacity to lower power amperage draw shall not be permitted.
E. The compressor(s) shall be equipped with a 60 Watt crankcase heater controlled by oil temperature.
F. The compressor shall employ a factory metered charge of Polyvinyl Ether (PVE) oil.
G. The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.
H. The compressor bearing(s) shall have Teflon™ coating.
I. The compressor(s) shall be protected with:
   (i) High Pressure switch
   (ii) Over-current /under current protection
   (iii) Oil sump sensor
   (iv) Phase failure
   (v) Phase reversal
   (vi) Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability.. The VRF outdoor unit shall have published_performance data for heating mode operation down to -13F on both heat pump and heat recovery systems.
J. Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

Inverter Compressor Controller(s)

A. The VRF outdoor unit shall be provided with a separate inverter compressor controller PCB for each compressor. Inverter compressor controllers that host more than one compressor shall not be accepted.
B. The inverter compressor controller shall be designed and programmed to utilize the entire range of operation of the connected compressor during cooling cycle operation and/or heating cycle operation.
C. Inverter compressor controllers programmed to limit the compressors heating or cooling capacity to reduce or limit power consumption is not acceptable.

Operational Sound Levels

A. Each single frame outdoor unit shall be rated with an operational sound level not to exceed 59.5 dB(A) when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their

equipment at other than the highest field selectable conditions shall not be allowed

B. A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement.

Sensors

A. Each outdoor unit module shall have
(i) Suction temperature sensor
(ii) Discharge temperature sensor
(iii) Oil level sensor
(iv) High Pressure sensor
(v) Low Pressure sensor
(vi) Outdoor temperature sensor
(vii) Outdoor unit heat exchanger temperature sensor

4.2 HEAT RECOVERY UNIT (HRU) (HEAT RECOVERY SYSTEMS ONLY)

General

A. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
B. HR unit casing shall be constructed with galvanized steel.
C. HR unit shall require 208-230V/1-phase/60Hz power supply.
D. HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.
E. HR unit shall be engineered to work with a three pipe VRF system comprising of
(i) High Pressure Vapor Pipe
(ii) Low Pressure Vapor Pipe
(iii) Liquid Pipe
F. HR units' main 3 pipe connections shall be capable of series or parallel pipe configuration.
G. The quantity of HR units that can be piped in series shall be limited to 16.
H. A single string of series piped HR units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 192MBh.
I. HR unit shall have 2, 3 or 4 ports, each port supporting one or more indoor units with a maximum connected capacity of 54 MBH.
J. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
K. Each port shall be capable of connecting from 1 to 8 indoor units.
L. Connection to Indoor units totaling greater than 54MBh nominal capacity shall be twinned to two adjacent ports of the HRU using a reverse Y-branch connector supplied by manufacture.
M. HR unit shall be internally piped, wired, assembled and run tested at the factory.
N. HR unit shall be designed for installation in a conditioned environment per specifications.
O. HR unit shall employ a liquid bypass valve.

P. HR unit shall have (2) two-position refrigerant valves per port.
Q. HR unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.
R. HR unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
S. HRU shall contain one double spiral sub-cooling heat exchanger per port.
T. HR unit shall not require a condensate drain or connection.
U. HR unit shall be internally factory insulated.
V. All field refrigerant lines between outdoor unit and HR unit and from HR unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.
W. The HR unit shall not exceed a net weight of 50 lbs.
X. HRU's shall not exceed a maximum equivalent pipe length of 8.2 feet.
Y. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat Recovery unit to allow the servicing of HR units, refrigerant circuit or the replacement of HR unit without evacuating the balance of the piping system.

Piping Capabilities

A. The elevation difference between indoor units on heat pump systems shall be 131 feet.
B. The elevation differences for heat recovery systems shall be:
(i) Heat recovery unit (HRU) to connected indoor unit shall be 49 feet
(ii) HRU to HRU shall be 49 feet
(iii) Indoor unit to indoor unit connected to same HRU shall be 49 feet
(iv) Indoor unit to indoor unit connected to separate parallel piped HRU's shall be 131 feet.
C. The acceptable elevation difference between two series connected HR units shall be 16 feet.

Controls

A. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
B. HR unit shall communicate with the indoor units via a 2-conductor shielded communications cable terminated using a daisy chain configuration. (see instructions regarding the termination of the shield)
C. The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.

4.1 INDOOR UNITS

General

A. Nominal cooling capacity ranges from 5,300 Btu/h to 96,000 Btu/h (model dependent) shall be factory assembled, wired, piped and run tested.

B. All indoor units shall be available as ducted, ductless or a combination of both, and shall be complete with factory mounted controls, fans, coils, electronic expansion valves (EEVs), condensate drain pans, condensate drain lift pumps (selected models) filter racks, return air temperature sensors, refrigerant pipe temperature sensors and wiring terminal blocks. The units shall have multiple-speed constant-flow fan assemblies with direct drive digitally commutated BLDC motors.

C. All indoor units shall be capable of real-time response and communication from smart load control and/or flexible capacity control commands and re-set as required super-heat, sub-cooling, sensible heat ratio, total coil capacity and fan control when requested by main processor Indoor units shall provide capacity verses implied load status information.

D. All indoor units shall be factory equipped with a single set of configurable dry contacts for use with integration of other controls, control of remote devices or to be controlled by other devices.

E. All indoor unit coils shall pressure tested with dry nitrogen to a minimum of 500 psi in the field, coils and indoor units containing coils not rated for 500 psi or more shall not be permitted.

F. The entirety of this indoor unit specification and unit options define the minimum acceptable VRF indoor unit requirements for this project. All indoor units provided shall include all features and capabilities.

END OF SECTION

SECTION 23 74 33
OUTSIDE AIR UNITS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 RELATED WORK: Related work specified elsewhere includes:

A. Section 23 0010 - Mechanical General Provisions

1.3 SUMMARY:

A. Outside air units shall meet the capacity and operating conditions indicated on the Design Drawings.

B. Each unit shall be tagged at the factory with its specific location on the job, including building floor, room/area served, and the unit designation shown on the Drawings.

C. All materials and equipment shall be asbestos free.

D. Unit performance shall be as scheduled on the Design Drawings.

E. All electrical components shall bear the U.L. label and shall be listed by Underwriters' Laboratories.

F. All components and work shall meet the applicable standards and codes by references included herein.

G. Units shall be manufactured in the United States of America.

1.4 REFERENCES:

A.	Air Conditioning and Refrigeration Institute	AHRI
B.	American National Standards Institute	ANSI
C.	Air Moving and Conditioning Association	AMCA
D.	American Society for Testing and Materials	ASTM
E.	American Society of Heating, Refrigeration & Air Conditioning Engineers	ASHRAE
F.	American Society of Mechanical Engineers	ASME
G.	American Welding Society	AWS
H.	Anti-Friction Bearing Manufacturers Association	AFBMA
I.	Commercial Standards	CS

J.	Factory Mutual Corporation	FM
K.	Industrial Risk Insurers	IRI
L.	Manufacturers' Standardization Society of the Valve & Fittings Industry (Standard Practice)	MSS SP
M.	National Electrical Code (NFPA 70)	NEC
N.	National Electrical Manufacturer's Association	NEMA
O.	National Fire Protection Association	NFPA
P.	Sheet Metal & Air Conditioning Contractors National Association	SMACNA
Q.	Steel Structures Painting Council	SSPC
R.	Underwriters Laboratories	UL
S.	United States Standard	USS

1.5 QUALITY ASSURANCE:

A. The manufacturer shall be regularly engaged in the manufacture of these components and shall have published complete catalog data on all products offered.

B. The manufacturer shall have been engaged in the manufacture of products offered for not less than five (5) years.

C. Fans shall have certified capacity, static pressure, fan speed, brake horsepower, and selection procedures in accordance with AMCA standards.

D. Refrigeration unit shall have certified capacity in accordance with ARI standards.

E. The unit shall be factory tested prior to shipment.

1.6 SUBMITTALS:

A. Equipment shop drawings shall be submitted for each equipment layout, showing plans and sections of proposed arrangement and size of each unit, including maintenance access, coil removal spaces, duct routing, structural clearances and the like. These shop drawings shall be submitted for approval, as required by Section 23 0010, regardless of manufacturer and equipment selected. Submit the following for approval in accordance with Section 23 0010:

1. Drawings indicating components, dimensions, weights and loadings, required clearances, location and size of all field connections, and assembly details for individual sections.

2. Product data indicating rated capacities, weights, accessories, vibration isolation components, electrical requirements, finishes of materials, and performance criteria for individual sections.

3. Complete sound performance data at design conditions (determined in accordance with ARI and AMCA Standards). Submit sound power ratings in decibel levels referred to 10^{-12} watts obtained in accordance with AMCA Bulletin 300 "Test Code for Sound Rating Air Moving Devices" for each individual unit at the specified performance.

4. Motor data indicating voltage, phase, frame size, RPM, efficiency, power factor and test results.

5. Fan performance data and fan curves indicating capacity, static pressure, fan speed, brake horsepower, plotted selection point, fan curve surge region and minimum capacity.

6. All equipment and component warranties.

7. Manufacturer's installation instructions.

8. Operation and Maintenance manuals to include manufacturer's descriptive literature, start-up and operating instructions, maintenance procedures and parts lists.

B. The manufacturer shall guarantee all units, components and performance data to meet or exceed the specified performance requirements.

C. Submit factory test report indicating all components and controls have been tested prior to unit shipment.

1.7 IDENTIFICATION:

A. Each unit shall be tagged at the factory with its specific location on the job, including location and the unit designation shown on the Drawing.

B. Provide nameplate on each unit and module as required by Section 23 0553 - Mechanical Identification.

1.8 WARRANTY:

A. Manufacturer shall provide a five year parts and labor warranty on each entire unit from date of final acceptance under provisions of Section 23 0010.

1.9 DELIVERY, STORAGE AND HANDLING:

A. Products shall be delivered to the site under provisions of Section 23 0010.

B. Products shall be stored and protected under the provisions of Section 23 0010.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Units

damaged by weather, construction activities, or mishandling shall be replaced at the Contractor's expense.

D. Any insulation that becomes wet due to exposure to weather shall be completely replaced. If units are double wall construction, the entire unit shall be replaced.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Acceptable manufacturers are Valent, Greenheck, or Trane approved equal, provided such equipment meets or exceeds the specifications and the scheduled performance requirements and will fit in the available space.

2.2 FANS:

A. Fan shall be double width, double inlet, backward inclined blade, or airfoil centrifugal or plenum type. (Fans with forward curved blades are unacceptable.) The fan shall be Class I or Class II. Fan performance shall be in accordance with AMCA 211 and 311 and comply with the requirements of AMCA Certified Rating Program. Fans shall bear the AMCA seal.

B. Inlet cones shall be spun or die formed.

C. Fan and drive shall be mounted on a spring-isolated structural base inside the fan housing. Spring mounts shall have a minimum 2" deflection rating. The fan housing shall be secured to the discharge opening panel with spring thrust restraints. Fans shall be internally isolated from the unit casing duct connection.

D. Fan housing shall be fabricated of minimum 16 gage thickness galvanized steel and include internal flexible connections on all units.

E. Fan wheels shall be fabricated of steel and painted with a minimum of one shop coat of zinc-chromate primer paint and one coat of galvanized enamel finish after fabrication.

F. Fan wheels and sheaves shall be keyed and fastened to the shafts with set screws.

G. Shafts shall be of steel, either solid or hollow, and ground and polished to tolerance on working surfaces.

H. Nonworking surfaces of shafts shall be coated with factory applied corrosion-proof coating.

I. Bearings shall be anti-friction type, self aligning, grease lubricated pillow-block ball bearings with lubrication fittings, and designed to prevent leakage of lubricant and entrance of dirt.

J. Design life shall be a minimum (not average) of 80,000 hours at the maximum operating speed.

K. Extend grease fittings to the casing door when bearings are located internally.

L. Prior to shipment, statically and dynamically balance fans on their own shafts in their own units at design speed.

M. Provide motor horsepower necessary to drive the fan at the air volume and static pressure scheduled on the Drawings plus 10 percent belt loss. Fan and motor shall be non-overloading at any point on the operating curve, not including motor service factor.

N. Fan shall be electric motor driven through a high capacity type V-belt drive.

O. Drives shall be protected with a belt guard of expanded metal wire mesh, or solid metal side panels with tachometer opening at motor and fan shafts. Shafts shall be drilled to receive tachometer.

P. Provide adjustable motor base and fixed pitch multiple-belt drive. Variable pitch drive pulley may be used on 30HP and smaller motors.

Q. The entire fan drive (sheaves, belts, keys and other items) shall be manufacturer rated at a minimum of 1.5 times the maximum horsepower required to drive the fan.

R. Fans and shafts shall be designed to operate without passing through the first critical speed.

2.3 UNIT CASINGS:

A. Walls and roof shall have an 18 gauge galvannealed steel outer skin with a 22 gauge inner liner except coil section shall be 22 gauge minimum thickness aluminum. Two inch, 1.5# density fiberglass insulation shall be secured between the inner and outer skins. All roof and side wall seams shall be positively sealed to prevent water and air leakage. All bolts and sheet metal screws that penetrate the unit casing shall be gasketed. Total casing air leakage shall not exceed 1-1/2% of rated air flow at 125% of maximum operating pressures.

B. Unit walls and roof shall be constructed of panels with special end flanges for maximum rigidity and minimum thermal bridging at joints. Tubular frame type construction shall not be accepted due to excessive thermal bridging at panel joints and associated potential for condensing moisture on exterior of unit casing.

C. Floors shall be constructed of 16 ga. aluminized steel, with continuous insulation. Insulation shall cover entire floor of unit, leaving no exposed metal for condensation to occur, and shall have a minimum insulating value of R8. Floors to have upturned flange around entire perimeter and around all interior chases to contain moisture within the unit. Multiple floor drain tubes shall be provided to route moisture to side drain connections. All drains and associated piping are to be fully welded and tested. Entire exterior of unit shall be painted with two coats corrosion and weather-resistant 100% acrylic latex paint.

D. Access shall be provided for inspection/maintenance of fans, motor & drives, filters, coils, drains, and all control components. Access doors shall be gasketed, insulated, double-wall constructed with heavy duty stainless steel hinges for rigidity and air tight enclosure.

E. Drain pan shall be continuously welded stainless steel with external condensate connection not less than one inch (1") pipe size. Drain pan shall be sloped to drain and thermally isolated from the unit casing with 1" insulation. All parts of the drain pan exposed to the air stream shall be protected with an antimicrobial coating to proclude growth and dissemination of micro-organisms.

F. The base of the package shall be an all welded structural "C" channel steel frame, and shall be painted with one coat of metal primer, followed by two coats corrosion resistant 100% acrylic latex paint. The frame shall have sufficient cross members to support the system without bending or deforming the casing to maintain waterproof integrity and proper equipment alignment. Lugs for lifting the unit shall be an integral part of the structural frame.

2.4 ENTHALPIC WHEEL (WHERE SCHEDULED):

A. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.

B. Latent and sensible energy transfer shall be provided through a enthalpy wheel, with a minimum total energy recovery effectiveness of 50% tested and certified to AHRI 1060-2005.

C. The heat exchanger frame shall be constructed with extruded 6063 aluminum rails.

D. The wheel shall be capable of handling regular contact with liquid water from either condensation or periodic cleaning while maintaining both the energy recovery effectiveness and 0% EATR rating.

E. The wheel shall be mold and bacteria resistance tested to ISO 846a and 846c with a rating of 0 for both.

F. The heat exchanger core shall comply with UL 723 and have a flame spread index of 25 or less and a smoke index of 50 or less.

G. Stainless steel drain pans shall be provided under entire heat exchanger to catch and drain condensation or water used in periodic cleaning.

2.5 DAMPERS:

A. All dampers shall be of the low leakage airfoil type with blade edge and side seals. Dampers shall be constructed of galvanized steel (14 ga. frames/16 ga. blades) with self-lubricating porous bronze bearings.

B. Outside air and exhaust air dampers shall be provided to prevent infiltration of unconditioned air into the building when the unit is not in operation. Interlock

with unit fan to open when fans are on.

2.6 COOLING COILS: DX type cooling/dehumidification coils shall be sized to provide moisture removal of the capacity indicated on the equipment schedule. Coils shall be fabricated of copper tubes, aluminum fins, galv. steel casings with performance certified by AHRI standards. All coils shall be fully tested for leaks. Coil drain pan(s) shall be fully welded, 16 ga. stainless steel and shall be sloped towards drain lines.

2.7 FILTERS: The supply and exhaust air filters shall be two-inch deep pleated cartridge type, providing an average efficiency of 30 percent by ASHRAE standard 52-75 test method. Filters shall be Farr 30/30 or equal. Face velocity throughout the filters shall not exceed 500 FPM at the unit's rated nominal capacity. Provide one set of filters for use during construction. Install one set of clean filters at completion of construction as directed by the Owner's representative.

2.8 HEATING: Unit shall be provided with AGA-certified, induced-draft, 8:1 turndown indirect gas furnace. Furnace assembly shall include the following items:
Electronic modulating gas valve.
Two-speed combustion fan.
409 stainless steel heat exchanger.

2.9 CONTROLS AND ELECTRICAL COMPONENTS:

A. Provide a unit mounted control panel with terminal block connections for unit controls indicated on the Control Drawings. Panel shall be provided with hinged access doors and mounted on the exterior of the unit in an accessible location.

B. Unit mounted controls for condensing unit shall include, but may not be limited to high refrigerant pressure, low refrigerant pressure to protect against refrigerant loss, and internal overload protection.

C. Electrical components shall be factory wired and include at least the following:

1. Main power distribution block with single point external power connection and disconnect switch for motors and controls and one disconnect for condensing unit.

2. Fused branch circuits for motors and controls and condensing unit.

3. Motor starters with overload protection and terminals for motor control.

4. Main control panel with starters and overloads, branch motor circuit fuses, fused control power transformer, and terminals for interconnecting control wiring (occupied mode, smoke detector safety, unit status, alarm).

5. DDC controls for staging cooling as required to control dewpoint space humidity, and supply air temperature.

6. Outside air and supply air temperature sensors and space humidity transducers shall be furnished with the equipment. Space humidity transducer shall be field mounted and wired by the Controls Contractor.

D. All electrical and control components shall be fully wired and factory tested prior to shipping.

E. All electrical components shall be U.L. listed.

F. Refer to Control Drawings for required controls.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install where shown on the Drawings. Provide required clearances for access, maintenance, and safety.

B. Refer to submittal data for specific dimensional information and installation instructions.

C. Install units on foundations.

D. Units shall be mounted level to ensure proper condensate flow.

E. Support all piping and ductwork independently of the unit to prevent excess noise, vibration transmission, and strain on connections. All connections to unit shall be made with approved flexible connections.

F. Follow specific rigging and installation instructions provided by the manufacturer in the shop drawing submittals.

G. Modules shall be assembled with gaskets between each section and in the order shown in the Contract Documents.

3.2 STARTUP AND TESTING:

A. Provide system preparation, startup, initial testing and placing in service.

B. Provide system testing and balancing per provisions of Section 23 0593.

3.3 EXTRA STOCK:

A. Provide one complete set of spare filters.

B. Provide one set of spare drive belts for each fan section.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.

2. Aluminum building wire rated 600 V or less.

3. Metal-clad cable, Type MC-HCF for Healthcare with ground wire.

4. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.03 DEFINITIONS

A. VFC: Variable-frequency controller.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

E. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.02 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B 800 and ASTM B 801.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

2.03 METAL-CLAD CABLE, TYPE MC-HCF

A. Description: A factory assembly of one or more current-carrying insulated conductors with redundant grounding provided in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. Comply with UL 1569 and 1063.

3. RoHS compliant.

4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit and multicircuit with color-coded conductors.

2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

G. Armor: Aluminum, interlocked.

H. Jacket: PVC applied over armor.

2.04 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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

1. 3M Electrical Products.

2. AFC Cable Systems; a part of Atkore International.

3. Gardner Bender.

4. Hubbell Power Systems, Inc.

5. Ideal Industries, Inc.

6. O-Z/Gedney; a brand of Emerson Industrial Automation.

7. TE Connectivity Ltd.

8. Thomas & Betts Corporation; A Member of the ABB Group.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway Type MC-HCF for Healthcare.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. VFC Output Circuits: Type TC-ER cable with braided shield.

J. Provide Type MC-HCF cable where required by NEC and local codes. Emergency power circuits shall be mechanically protected as specified by NEC 517.30 (C) (3).

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.04 CONNECTIONS

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

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.

b. Test bolted connections for high resistance using one of the following:

1) A low-resistance ohmmeter.

2) Calibrated torque wrench.

3) Thermographic survey.

c. Inspect compression-applied connectors for correct cable match and indentation.

d. Inspect for correct identification.

e. Inspect cable jacket and condition.

f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

g. Continuity test on each conductor and cable.

h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.

2. Results that comply with requirements.

3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
1) Test wells.
2) Ground rods.

3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, by 24” long with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.3 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
   a. Material: Die-cast zinc alloy.
   b. Listed for direct burial.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 30 inches below grade.

2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 18 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

H. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 30 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Substations and Pad-Mounted Equipment: 5 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.

2. Construction requirements for concrete bases.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
   a. Hangers.
   b. Steel slotted support systems.
   c. Trapeze hangers.
   d. Clamps.
   e. Turnbuckles.
   f. Sockets.
   g. Eye nuts.
   h. Saddles.
   i. Brackets.
2. Include rated capacities and furnished specialties and accessories.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. B-line, an Eaton business.
   c. ERICO International Corporation.
   d. Flex-Strut Inc.
   e. G-Strut.
   f. Haydon Corporation.
   g. Metal Ties Innovation.

h. Thomas & Betts Corporation; A Member of the ABB Group.
i. Unistrut; Part of Atkore International.
j. Wesanco, Inc.

2. Material: Galvanized steel.
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) B-line, an Eaton business.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

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

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.
5. Handholes and boxes for exterior underground cabling.

1.03 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 - PRODUCTS

2.01 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Electri-Flex Company.

4. FSR Inc.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Southwire Company.
7. Thomas & Betts Corporation; A Member of the ABB Group.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.

2. Coating Thickness: 0.040 inch, minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. FMC: Comply with UL 1; zinc-coated steel or aluminum.

I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:
   a. Material: Steel.
   b. Type: Compression.
3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

K. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems; a part of Atkore International.
2. Anamet Electrical, Inc.

3. CANTEX INC.
4. CertainTeed Corporation.
5. Electri-Flex Company.
6. FRE Composites.
7. RACO; Hubbell.
8. Thomas & Betts Corporation; A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

2.03 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, 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. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.04 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Crouse-Hinds, an Eaton business.
3. FSR Inc.
4. Hoffman; a brand of Pentair Equipment Protection.
5. Hubbell Incorporated.
6. Milbank Manufacturing Co.
7. O-Z/Gedney; a brand of Emerson Industrial Automation.
8. RACO; Hubbell.
9. Thomas & Betts Corporation; A Member of the ABB Group.
10. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

M. Gangable boxes are prohibited.

N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.05 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armorcast Products Company.
   b. Oldcastle Enclosure Solutions.
   c. Oldcastle Precast, Inc.
   d. Quazite: Hubbell Power Systems, Inc.
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.

4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.06 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.

7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each

end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.05 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.06 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.07 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.

2. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
   b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.
2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. HOLDRITE.

2.04 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.
B. Comply with NFPA 70.
C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
D. Comply with ANSI Z535.4 for safety signs and labels.
E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.

2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.
b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral: White.

6. Color for Equipment Grounds: Green.

7. Colors for Isolated Grounds: Green with white stripe.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

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

a. Brady Corporation.
b. emedco.
c. Grafoplast Wire Markers.
d. Marking Services, Inc.
e. Panduit Corp.
f. Seton Identification Products.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.
d. Seton Identification Products.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, polyester flexible label with acrylic pressure-sensitive adhesive.

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

a. Brady Corporation.
b. emedco.
c. Ideal Industries, Inc.
d. Panduit Corp.
e. Seton Identification Products.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.

4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm)for raceway and conductors.

b. 3-1/2 by 5 inches (76 by 127 mm)for equipment.

c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

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

a. Brady Corporation.
b. Panduit Corp.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

a. Carlton Industries, LP.
b. Ideal Industries, Inc.
c. Marking Services, Inc.
d. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

C. Tape and Stencil: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and is 12 inches (300 mm) wide. Stop stripes at legends.

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

a. HellermannTyton.
b. LEM Products Inc.
c. Marking Services, Inc.
d. Seton Identification Products.

D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

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

a. Carlton Industries, LP.
b. Seton Identification Products.

E. Underground-Line Warning Tape:

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

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
d. Marking Services, Inc.
e. Seton Identification Products.

2. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Type:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches (75 mm).
c. Overall Thickness: 5 mils (0.125 mm).
d. Foil Core Thickness: 0.35 mil (0.00889 mm).
e. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
f. Tensile according to ASTM D 882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be [1 inch (25 mm)].

2.6 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. LEM Products Inc.
e. Marking Services, Inc.
f. Panduit Corp.
g. Seton Identification Products.

B. Write-on Tags:

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

a. Carlton Industries, LP.

b. LEM Products Inc.
c. Seton Identification Products.

2. Polyester Tags: 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment.

3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

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

a. Carlton Industries, LP.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.

3. 1/4-inch (6.4-mm) grommets in corners for mounting.

4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Laminated Acrylic or Melamine Plastic Signs:

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2. Engraved legend.

3. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick).

b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.

c. Engraved legend with black letters on white face.

d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting.

e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

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

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).

3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 7000 psi (48.2 MPa).

3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).

5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "LIFE SAFETY BRANCH"

2. "CRITICAL BRANCH"

3. "EQUIPMENT BRANCH"

M. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.

2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

W. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

2. Limit use of underground-line warning tape to direct-buried cables.

3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Metal Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

Y. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

Z. Write-on Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

AA. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

BB. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

CC. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

DD. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch- (75-mm-) high, black letters on 20-inch (500-mm) centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 30-foot (10-m) maximum intervals.

D. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

E. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "LIFE SAFETY BRANCH"

2. "CRITICAL BRANCH"

3. "EQUIPMENT BRANCH"

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive vinyl tape to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

I. Conductors to Be Extended in the Future: Attach write-on tags to conductors.

J. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to raceways concealed within wall.

3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.

2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.

b. Controls with external control power connections.

P. Arc Flash Warning Labeling: Self-adhesive labels.

Q. Operating Instruction Signs: Self-adhesive labels .

R. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

S. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.

2. Outdoor Equipment: Laminated acrylic or melamine sign.

3. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Emergency system boxes and enclosures.
h. Enclosed switches.
i. Enclosed circuit breakers.
j. Enclosed controllers.
k. Push-button stations.
l. Power-transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Monitoring and control equipment.

END OF SECTION

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Molded-case switches.
6. Enclosures.

1.03 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and Insert calculation program format electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in [PDF] [and] <Insert calculation program format> electronic format.

1.06 FIELD 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 and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.02 FUSIBLE SWITCHES

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.

2.03 NONFUSIBLE SWITCHES

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.

4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

5. Lugs: Mechanical type, suitable for number, size, and conductor material.

6. Service-Rated Switches: Labeled for use as service equipment.

2.04 MOLDED-CASE CIRCUIT BREAKERS

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 167 deg F (75 deg C) rated wire.

F. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.

G. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.

2. Long- and short-time pickup levels.

3. Long- and short-time time adjustments.

4. Ground-fault pickup level, time delay, and I-squared t response.

H. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.05 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

D. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.02 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. Outdoor Locations: NEMA 250, Type 3R.

3.03 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.04 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION

SECTION 26 51 19
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the

National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.06 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.08 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61 or IEC 60061-1.

G. CRI of minimum 80. CCT of 3000 K.

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: As indicted on the drawings.

1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.02 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. 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.

C. Diffusers and Globes:

1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.

b. Lamp diameter, shape, size, wattage, and coating.

c. CCT and CRI for all luminaires.

2.03 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.04 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" 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 luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.

3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.07 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES:

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
C. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
D. ANSI/NEMA MG 1 - Motors and Generators.
E. ANSI/NFPA 70 - National Electrical Code.
F. EPAct - U.S. Energy Policy Act of 1992.
G. UL - Underwriters Laboratory.
H. ETL Testing Laboratory
I. CSA - Canadian Standards Association

1.03 SUBMITTALS:

A. Submit product data clearly indicating manufacturer, horsepower, voltage, phase, efficiency, service factor, enclosure type, maximum amps, dimensions, and terminations for each motor.

B. Submit manufacturer's installation instructions.

C. Submit operation and maintenance data. Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.04 REGULATORY REQUIREMENTS:

A. Conform to National Electric Code.

B. Motors shall be UL or ETL listed.

C. Motor Efficiency shall meet or exceed the latest requirements of the U.S. Energy Policy Act of 1992.

D. Motors shall be tested in accordance with standards of ANSI/NEMA MG1 and conform to the standard’s requirements for sound power, insulation resistance and dielectric strength.

E. Motors shall be designed for continuous operation in 40 degrees C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor, and motor enclosure type.

1.05 WARRANTY: Contractor shall provide one year warranty from date of final inspection and acceptance.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS:

A. Motor enclosure type, horsepower, RPM, and efficiency type shall be as scheduled on the Drawings.

B. Motor Sizing: Motors shall be sized to not overload or exceed nameplate horsepower (without including service factor) under any conditions of operation of the driven equipment. Motors shall be at least the horsepower indicated or specified.

C. Variable Frequency Drive Motors: Motors for use with variable speed drives shall be sized and insulated for proper continuous duty operation within the manufacturer's rated temperature limitations at all operating speeds and loads.

D. Nameplates: Each motor shall have a visible nameplate indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency.

E. Connection Boxes: Motors shall include conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame.

2.02 ACCEPTABLE MANUFACTURERS:

A. Premium Efficiency (Three Phase):

1. Baldor Super E Series
2. General Electric Energy Saver Series
3. Lincoln Electric Energy Efficient Series
4. Reliance XE Series
5. Magnetek (Century) E-Plus III

2.03 THREE PHASE POWER - SQUIRREL CAGE INDUCTION MOTORS:

A. Motors shall be premium efficiency squirrel cage induction type, NEMA Type B or better, three phase, 60 Hz, continuous duty, 40 F ambient, with 1.15 service factor and grease lubricated bearings.

B. Insulation Requirements:

1. Constant Speed ODP Motors: NEMA Class B or better.

2. TEFC, Mill and Chemical, or Explosion-Proof Motors: NEMA Class F.

3. Motors for Variable Frequency Drives: NEMA Class F or better. Insulation shall comply with the requirements of the VFD manufacturer.

C. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.

D. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for re-lubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.

2.04 SINGLE PHASE POWER - SPLIT PHASE MOTORS:

A. Starting Torque: Less than 150 percent of full load torque.

B. Starting Current: Up to seven times full load current.

C. Breakdown Torque: Approximately 200 percent of full load torque.

D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.

E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.05 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS:

A. Starting Torque: Exceeding one fourth of full load torque.

B. Starting Current: Up to six times full load current.

C. Multiple Speed: Through tapped windings.

D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.06 SINGLE PHASE POWER - CAPACITOR START MOTORS:

A. Starting Torque: Three times full load torque.

B. Starting Current: Less than five times full load current.

C. Pull-up Torque: Up to 350 percent of full load torque.

D. Breakdown Torque: Approximately 250 percent of full load torque.

E. Motors: Capacitor in series with starting winding; capacitor-start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.

F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated ball bearings.

G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.07 DISCONNECT SWITCHES: Provide disconnect switches for each motor provided under this Specification Division unless specifically indicated as furnished by the Electrical

Contractor.

2.08 MOTOR STARTERS: Starters not included as an integral part of equipment or specifically indicated to be provided by the Electrical Contractor, shall be furnished by the Mechanical Contractor and installed by the Electrical Contractor for all motors provided under this Specification Division.

PART 3 - EXECUTION

3.01 APPLICATION:

A. Motors drawing less than 600 Watts and intended for intermittent service may be proprietary to equipment manufacturer and need not conform to these Specifications.

B. Motors shall be open drip-proof type, except where specifically noted otherwise.

C. Single phase motors for shaft mounted fans or blowers shall be permanent split capacitor type.

D. Motors located in exterior locations shall be totally enclosed type.

3.02 MOTOR EFFICIENCY: Minimum required full load nominal motor efficiency for three phase motors shall comply with NEMA Premium Efficiency Motor Standards Publication MG-1.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 – GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 PIPING SYSTEMS: Supports and anchors for piping systems shall be in accordance with ANSI B31.1, "Power Piping" to maintain required pitch of lines, prevent vibration and provide for expansion and contraction movement.

1.03 REFERENCES:

A. ASME B31.1: "Power Piping"
B. MSS SP-58: "Pipe Hangers and Supports - Materials, Design and Manufacture"
C. MSS SP-69: "Pipe Hangers and Supports - Selection and Application"
D. MSS SP-89: "Pipe Hangers and Supports - Fabrication and Installation Practices"

1.04 QUALITY ASSURANCE:

A. Materials and fabrication procedures shall be subject to inspection and tests in mill, shop, and at the site. Test shall be conducted by a qualified inspection agency employed by the Owner.

B. Such inspections and tests shall not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.

C. Contractor shall promptly remove and replace materials or fabricated components which do not comply with requirements of Contract Documents.

D. Welded construction shall comply with AWS Code for procedures, appearance, and quality of welds and for methods used in correcting welding work.

1.05 SUBMITTALS:

A. Submit shop drawings in accordance with Section 23 00 10 - Mechanical General Provisions.

B. Submittals shall be provided for hanger and support types according to pipe size, pipe service type, and exposure classification.

C. Submittals shall include manufacturer's product data, protection saddle product sheets, coating/finish product data sheets, and fabrication

drawings necessary to confirm compliance with specified hanger types and details on the Drawings.

D. Submittals are required for all fabricated materials and assemblies to be

furnished and delivered to the site.

E. Welded connections shall be indicated with standard AWS symbols (showing size, length, and type of each weld).

F. Submit coordination drawings in accordance with Section 23 00 10 - Mechanical General Provisions. Drawings shall also include the following:

1. Location and type of each hanger and support.

2. Total loads of pipe, fittings, valves, insulation, supports and pipe contents that will be applied at each attachment point to the building structure.

3. Type and/or detail of each attachment point proposed to be used for connection to the building structure.

4. Contractor shall be prepared to demonstrate calculations used to determine loads at each attachment point, upon request by the Engineer.

G. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, the Contractor shall submit a certification stating that such requirements have been complied with.

PART 2 - PRODUCTS

2.01 MANUFACTURERS: Support and hanger products are specified below by reference to Grinnell or Michigan figure numbers. Equivalent products by Bergen-Paterson, Grinnell, B-Line, Corner & Lada, Michigan Hanger Co., Gulf States, F&S Central, Crawford, Modern, or Pipe Shields, Inc. will be accepted.

2.02 MISCELLANEOUS SUPPORT MATERIALS:

A. Rolled Steel Plates, Shapes, and Bars: ASTM A36

B. Cold-Formed Steel Tubing: ASTM A500, Grade B; Fy = 46 ksi

C. Steel Pipe: ASTM A53, Type E, Non Tested, Grade B; Fy = 35 ksi

D. Anchor Bolts: ASTM A36

E. High-Strength Threaded Fasteners: Heavy hexagon bolts, nuts, and hardened washers complying with ASTM A325.

F. Electrodes for Welding: Comply with AWS Code, ASTM A233-E70 Series electrodes.

2.05 SHOP COATING SYSTEMS:

A. Shop Primer and Paint: Refer to Specification 23 00 10.

B. Electro-Plated Galvanized: ASTM B633 SC1 or SC3 coating of zinc on steel by electrolysis from a bath of zinc salts. This coating is pure zinc and adheres to the steel with a molecular bond.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS:

A. Provide all hangers, miscellaneous steel, brackets and attachments necessary to adequately support equipment, ductwork, and piping installed under this Division.

B. All hangers, miscellaneous steel, brackets and attachments shall be connected only to the base building structure. No attachment of any kind shall be made to the roof deck or floor deck metal. Proper expansion anchors may be used through the floor deck metal and into the structural floor above.

C. Hangers shall not be shared by other trades. Each trade shall provide hangers and supports for his work. The use of shared hangers shall be specifically approved by the Engineer.

D. Steel supports and fastening devices shall be of structural quality. Steel supports shall be prime painted before installation. Any primer removed or damaged during installation shall be repainted or touched up with primer after installation.

E. All roof mounted equipment shall be supported and fastened to the structure to comply with wind load requirements designated by the North Carolina Building Code. Mechanical Contractor shall furnish equipment support structural calculations at the request of the Engineer.

F. The Mechanical Contractor shall coordinate closely with the Plumbing Contractor, Electrical Contractor, and Controls Subcontractor to confirm quantities and sizes of all utilities scheduled or required to be supported from the pipe, duct, or equipment supports. The Mechanical Contractor shall furnish locations, spacing, quantities and the like to the General Contractor for coordinating the installation with the structure. Refer to pipe support details for details of the permitted attachment types to the building structure.

G. Concrete inserts required for hanging mechanical or plumbing piping, pipe supports, pipe trapeze hangers, HVAC ductwork, and the like, shall be furnished by the Mechanical Contractor to the General Contractor for installation as construction work progresses. Mechanical Contractor shall be responsible for all quantities of such inserts and for sizing inserts to support the intended load. The Mechanical Contractor shall coordinate closely with the Plumbing Contractor, Electrical Contractor, Controls Contractor, and Fire Protection (Sprinkler) Contractor to confirm quantities and sizes of all utilities scheduled or required to be supported from the pipe, duct, or equipment supports. The Mechanical Contractor shall furnish locations, spacing, quantities and the like to the General Contractor for coordinating the installation with the structure. Refer to Structural Drawings for details of the permitted attachment

types and locations respective to the building structure.

3.02 SUPPORT AND ATTACHMENTS:

A. Material and finish for hangers and supports shall be the same as the hanger type required for each location in the project.

B. Where pipe cannot be suspended from overhead supports, use substantial cast iron or welded steel wall brackets or trapeze supports to support the hangers, pipe seats, or roll stands, as conditions demand and as approved by the Engineer.

C. Construct fabricated supports and brackets of structural grade miscellaneous steel and fasteners. Black or plain steel components, which are not specified to have a special finish, shall be delivered to the job site with a prime coat of paint. Touch up primer after fabrication and after installation. All exposed miscellaneous support steel shall, as a minimum, be prime coated with paint to minimize the potential for rusting.

D. Provide all miscellaneous steel, bridging, brackets, anchors, frames, bracing, plates, bolts, nuts, washers, and the like, necessary to properly support piping. All steel, hangers and attachments shall be mounted to the building structural steel frame, concrete or masonry walls, structural concrete floors or concrete structural members.

E. No attachments of any kind shall be made to the roof deck metal or cellular roof deck unless approved in writing by the Engineer. No attachments of any kind shall be made to lateral cross bracing between trusses unless approved in writing be the Engineer.

F. Attach hangers to structure using mechanical anchors rated for not less than two times the calculated hanger load.

G. Material and finish for all components shall be same as the hanger type required for each location.

H. Provide bracing and supports for all vertical pipe risers, with riser clamps at each floor level.

I. All attachments, supports and hangers shall be aligned with the building structure. Hangers rods shall be installed vertically. Arrangement and fabrication of all supports is subject to Engineer's approval. Skewed or bent hanger materials shall be straightened or replaced.

J. Solid or perforated strap hangers and wire hangers will not be permitted, except for temporary supporting during construction.

K. Each trade shall provide hangers independent of other trades. Ceiling grids, piping, ductwork, electrical and communication conduit, equipment, and the like shall all be supported independently.

3.03 WELDED ATTACHMENTS:

A. All welded type support components shall be in accordance with MSS SP-58.

B. All attachments welded to the pipe shall be in accordance with MSS SP-58. Attachments welded directly to the pipe shall be compatible with the chemical composition of the pipe material and the process of attachment shall conform to the requirements for fabrication of the pipe with regards to preheating, welding, and stress relieving.

C. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of AISC Specification for the Design, Fabrication, and Erection of Structural Steel Buildings.

D. All welds shall be performed by certified welders in compliance with the welder's qualifications as specified in Section 23 00 10 - Mechanical General Requirements.

E. Repaint all existing or new building steel where the paint is scraped or burned away during welding operations to match existing paint finishes.

3.04 PRIMING AND PAINTING:

A. All metal surfaces on carbon steel supports, anchors and seals indoors shall be primed.

B. All metal surfaces on carbon steel supports, anchors, and seals exposed to outdoor conditions shall be hot dipped galvanized.

C. Immediately after surface preparations, apply shop paint in accordance with manufacturer's printed instructions, and at a rate to provide a uniform dry film thickness as specified.

D Use painting methods that will result in full coverage of joints, corners, edges, finished welds, and all surfaces.

E. Painting materials and methods shall comply with Specification 23 00 10.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES:

A. ANSI/ASME A13.1 - Scheme for the Identification of Piping Systems.
B. ANSI Z53.1 - Safety Color Code for Marking Physical Hazards.

1.03 SUBMITTALS: Submit shop drawings in accordance with Section 23 00 10. Submittals shall include, but not be limited to, the following:

A. Legend, list of wording, abbreviations, symbols, letter size, and color-coding for all mechanical identification.
B. Pipe identification; including color scheme, size, color field and legend.
C. Valve chart and schedule; including valve tag number, location, function.
D. Valve tags showing material, size, lettering and attachment.
E. Stencils and stencil paint.

PART 2 – PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS (Identification Markers and Components):

A. Almetek Industries
B. Brady USA, Inc.
C. Craftmark Identification Systems
D. Panduit Corporation
E. Seton Name Plate Company

2.02 MATERIALS:

A. Plastic Nameplates: Laminated three-layer plastic with engraved black letters on light contrasting background color.

PART 3 – EXECUTION

3.01 PREPARATION:

A. Degrease and clean surfaces to receive adhesive or paint for identification materials.

B. Install identification system items prior to final inspection.

C. Where piping and other surfaces are specified to be painted, install identification system after painting has been completed.

3.02 INSTALLATION:

A. Plastic Nameplates: Install with stainless steel or cadmium plated screw, bolt, or rivet. Adhesive fastening shall not be used.

B. Metal Tags: Install with brass or stainless steel corrosive-resistant chain.

C. Equipment: Identify all equipment with plastic nameplates. Small devices, such as in-line pumps, may be identified with metal tags.

D. Controls: Identify control panels, control components outside panels, and control junction boxes with plastic nameplates.

E. Valves: Identify valves in main and branch piping with metal tags.

F. Piping: Identify piping, concealed and exposed, with stencils. Metal tags may be used on small diameter piping. Identify service and flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 30 feet apart on straight runs including risers and drops, adjacent to each valve and "T", at each side of penetration of structure or enclosure, at each obstruction, and at each item of equipment and control.

G. Access Doors: Provide plastic nameplate at or on each access door identifying item or items behind door, such as valve, air vent, drain, and the like.

H. Provide metal ceiling tacks with ¾" diameter color coded head on ceiling grid where HVAC isolation valves are installed above.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 REFERENCES: (Latest edition for listed references shall apply.)

A. ASHRAE Handbook - Fundamentals (latest edition): Chapter. 7 - "Sound and Vibration Fundamentals", and Chapter 13 - "Measurement and Instruments".
B. ASHRAE Handbook - 1991 HVAC Applications: Chapter. 34 - "Testing, Adjusting, and Balancing".
C. ASHRAE Standard 111-1988: "Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems".
D. AABC - "National Standards for Total System Balance, 4th edition".
E. NEBB - "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".
F. SMACNA - "HVAC Systems - Testing, Adjusting & Balancing"
G. SMACNA - "HVAC Air Duct Leakage Test Manual"
H. SMACNA - "HVAC Duct Construction Standards - Metal and Flexible"

1.03 ACCEPTABLE TEST AND BALANCE CONTRACTORS: Acceptable Test and Balance Contractors shall be as follows:

A. Air Balance Corporation of Greensboro, NC
B. Phoenix Agency of Winston Salem, NC
C. Test and Balance Corporation of Winston Salem, NC
D. Joseph M. Gamewell Associates of Salisbury, NC
E. Mid Atlantic Test and Balance of South Boston, VA.
F. Envirotrol of Greensboro, NC.
G. Others as approved in writing by the Engineer

1.04 SUBMITTAL REQUIREMENTS:

A. Submit four (4) typed copies of proposed test procedures for approval in accordance with shop drawing requirements of Section 23 00 10 - Mechanical General Provisions. Include description of procedures, instruments and equipment to be used, catalog data on instrumentation, planned manpower required, and proposed schedule. Provide this information for each type of test, and for each system to be tested. Tests will be specific for the equipment and systems on this project. A complete, blank test sheet shall be provided for each equipment type and test requirement.

B. Submit four (4) typed copies of test schedules of readings taken during testing and balancing operations, indicating the required reading, the first reading taken, and the final balance reading for the items listed in Part 3 - Execution, of this section in accordance with shop drawing requirements of Section 23 00 10 - Mechanical General Provisions. Readings shall be taken with clean operating strainers and filters in place, but with start-up strainers removed.

C. Submit instrument calibration report along with the test schedules of readings taken during testing and balancing operations.

D. Submit Component Deficiency Report(s) as required to provide information helpful in determining the cause of the problem(s) and to provide feedback to the equipment manufacturer, designer, or installer. Submit such reports as soon as the problem becomes evident, before proceeding with remaining related work, and, where practical, provide recommendations for correcting the apparent system component failure. Furnish documentation of confirming test data and observations as required to substantiate the reported problems.

E. All information shall be assembled in a three-ring binder with index tabs to identify each item of major equipment and each system.

1.05 SCOPE OF WORK:

A. SYSTEM PREPARATION, START-UP, INITIAL TESTING AND PLACING IN SERVICE shall be performed by the Mechanical Contractor. The Mechanical Contractor shall be responsible for performing initial equipment and system checks and system start-up in order to prepare the system(s) for testing, adjusting, and balancing by the independent Testing and Balancing (TAB) Contractor. The Mechanical Contractor shall furnish specific project information to the TAB Contractor, including, but not limited to, the following: Two (2) sets of all submittal data, complete shop drawings, duct and pipe fabrication or layout drawings, contract drawings, project specifications, controls system(s) shop drawings, and initial system testing reports for use by the TAB Contractor.

B. SYSTEM TESTING AND BALANCING shall be performed by an independent Testing and Balancing (TAB) Contractor who specializes in the practice of testing, adjusting and balancing of mechanical equipment and systems. The TAB Contractor shall be AABC or NEBB certified.

C. The TAB Contractor shall perform a pre-construction review of the Contract Documents in order to become familiar with the project. TAB Contractor shall advise the Mechanical Contractor regarding potential problems that may impact TAB services and submit a written report to be routed as a shop drawing. The TAB Contractor shall also be available to observe construction progress to identify and minimize TAB or operation problems, witness and certify Contractor's leak tests and manufacturer's performance tests as required.

D. The TAB Contractor shall test existing systems noted herein and provide a report for the existing equipment.

E. The TAB Contractor shall test, adjust and balance all systems until design function and operation are achieved. All work shall be performed in strict accordance with appropriate sections of the AABC or NEBB Standards, the ASHRAE Handbooks, and these Specifications.

F. COMMISSIONING REQUIREMENTS: The TAB Contractor shall provide full time on-site support to commissioning authority in TAB validation. Refer to Specification Section 23 08 00, Mechanical Commissioning Requirements for additional requirements.

G. The TAB Contractor shall participate in the instruction and training of the Owner's operating personnel. The TAB Contractor shall correct any deficiencies for a period of one year following substantial completion and Owner acceptance of final balancing reports.

1.06 SEASONAL TESTING REQUIRED: Testing and balancing of all systems and equipment shall be performed at full load, during seasonal operating periods as required to obtain complete data for all equipment. Testing and balancing shall be repeated during different outdoor conditions as required to verify, test, and report equipment operating capacity at design conditions.

1.07 INSTRUMENTS:

A. The following instruments shall be furnished by the TAB Contractor for the purpose of performing systems testing and adjusting as specified in this section. Instruments required shall include, but not be limited to, the following:

1. Electrical: Digital volt, ohm, clamp-on amp, 1/2% accuracy
   Digital Wattmeter

2. Air: Alnor velometer (optional if Shortridge Velprobe is used)
   Micromanometer - Shortridge electronic with velocity probe and grid.
   8", 18", 36" and 60" ASME pitot tubes
   1/4" oil filled manometer (0-1" inclined)
   Shortridge or Alnor balancing cones
   Aspirating smoke generator
   Pressure fan for leak testing
   Superior Smoke bombs

3. RPM: Stroboscope: Digital - 1% $\pm$ RPM accuracy
   Digital tachometer: 1% $\pm$ RPM accuracy

4. Water: -30" Hg to 60 psi pressure gauge 1/2% accuracy
   0 to 200 psi pressure gauge 1/2% accuracy
   0 to 36" Hg manometer
   0-200' digital differential pressure meter

5. Temperature: Digital thermometer 1/10^{o} resolution, 1% accuracy

   Surface and immersion probes for thermometer
   Wet-bulb wicks and fans

6. Thermometer: 30 to 120^{o} 0.2^{o} 16" mercury

7. Air Quality: CO_2 analyzer

8. Noise: ANSI Type 1 meter w/octave band analyzer

9. Vibration: IRD or equal w/octave band analyzer

B. All meters shall be checked and calibrated with primary instruments prior to beginning any tests on this project. Voltmeters and other instruments that

cannot be checked shall be laboratory calibrated at reasonable intervals of not more than one year. Magnehelic or dial type differential pressure gauges may be used only for preliminary or non-certified work with their ranges, after calibration using the fluid filled manometers.

PART 2 - PRODUCTS

Not Applicable.

PART 3 - EXECUTION

3.01 TESTING, ADJUSTING AND BALANCING (GENERAL):

A. The Contractor shall engage the services of an independent TAB Contractor who specializes in the practice of testing, adjusting and balancing mechanical equipment and systems. Testing Contractor shall test, adjust and balance all systems until design function and operation are achieved.

B. TAB Contractor shall demonstrate performance of design function and operation for each system to the Engineer.

C. Testing, adjusting and balancing shall be performed in accordance with the recommended procedures of the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB).

D. Perform testing specified in this section in the presence of the Engineer. Local or state authorities having jurisdiction shall be given due notice of the tests as may be required by them, and acceptance of the work by the Engineer will be contingent upon acceptance by the public authority.

E. All system equipment shall be inspected, adjusted, and tested after installation. Adjustments shall be made and tests shall be repeated as often as necessary to insure that the equipment operates as specified.

F. Furnish all necessary equipment and assume all costs involved to perform all testing and balancing.

G. Tests of piping systems shall be conducted before connections to equipment are made, and before piping is insulated and/or concealed.

H. Systems found to have leaks shall be retested after leaks have been repaired.

I. The TAB Contractor shall cooperate with the Mechanical Contractor, Controls Contractor, and Commissioning Agent in performing all testing required and adjustments needed to achieve intended system performance.

J. Balancing of each system shall not be done until the system has been completed and is fully operational. Where manufacturer's startup is required, balancing shall be performed after manufacturer has certified that startup is complete.

K. Unless noted otherwise, take all balancing readings with clean strainers and filters in place.

L. Instruments shall be calibrated prior to balancing. Types, serial numbers, and

dates of calibration of all instruments shall be listed in the final balance reports.

M. After cleaning and testing of individual equipment items, test each system to determine that all items perform as integral parts of the system. Make corrections and adjustments to produce the specified conditions.

N. The Contractor shall make any changes in pulleys, belts, motors, dampers and valves, and add any dampers and valves, as required for achieving correct air and water balancing.

O. Equipment provided with variable frequency drives shall be balanced at 100% speed to allow drive operation in the bypass mode (maintenance, servicing, etc.).

P. Contractor shall maintain records of all inspections and tests performed on all systems. Records shall indicate which systems were tested, date of test, test witness, test conditions (be specific), test pressure and duration, test results, weather conditions, visual inspections, percent of system installation completed at time of test, specific test observations, and pertinent statements for the purpose of qualifying results or observations and number of tests required to achieve a successful test.

Q. The final test and balance report shall include as a minimum, all data indicated in test schedules included herein. Also, include records of inspections and tests in the final project documentation.

3.02 DUCTWORK AND AIR HANDLING EQUIPMENT TESTS: (Start-up and Placing in Service)

A. Inspect all main duct systems as work progresses. Smoke test the entire system if the leaks are apparent. Seal all duct joints with specified sealants. Visually inspect all air handling units, A/C units, plenums, coil casings, filter boxes, and accessories and the connections to the ductwork systems. Seal leaks and correct mechanical problems as required. Verify that all access doors and panels are gasketed and have operable latches. Outlets or taps shall be covered with plastic during testing.

B. Adjust belts and align drives for all rotating equipment. Lubricate bearings, dampers, etc., and check systems for excessive vibration and noise levels. Make adjustments necessary to prepare systems for final testing and balancing.

3.03 DUCTWORK LEAKAGE TESTS

A. Test ductwork as work progresses in accordance with SMACNA "Air Duct Leakage Manual: with all handling equipment, connecting ductwork, dampers, accessories and air outlet and inlets in place.

B. Test pressure shall be equal to the specific duct pressure class rating, except smoke exhaust ductwork which shall be pressure tested to 1.5 times design pressure with less than 5% leakage in accordance with Building Code Section 909.10.2.

C. Perform duct leakage tests for all ductwork and submit test reports to Engineer.

3.04 DUCTWORK SYSTEMS ADJUSTING AND BALANCING:

A. In cooperation with the Mechanical Contractor, the Controls Contractor, Owner, and Engineer, set adjustment of controls to operate as specified.

B. Adjust fan speeds, duct systems and components to provide air quantities within $\pm$ 5 percent of specified requirements under minimum and maximum flow conditions at each air inlet, outlet and variable air volume terminal unit.

C. Measure air quantities in main and branch ducts by traversing cross sectional area of duct with pitot tube. Ducts having minimum velocities of 1000 feet per minute or more shall be measured with inclined manometers (draft gage) or magnehelic gages. Ducts having velocities of less than 1000 feet per minute shall be measured with micromanometers, hook gages, or similar low pressure instruments. Openings in ducts for pitot tube insertion shall be accomplished by installation of instrument ports. When not in use, ports shall be sealed with plastic "snap-plugs". Diffuser, grille, and register air quantities shall be determined by direct reading velocity meters.

D. Obtain design air quantities in main ducts by adjusting fan speeds. Then adjust branch duct air quantities by volume or splitter dampers.

E. After testing and adjusting branch ducts, terminal units, grilles, and the like, retest main duct air quantities. Re-adjust if required.

F. Permanently and legibly scribe, punch, or paint mark dampers after air balance is complete to enable them to be restored to their correct position if disturbed at any time.

G. Test fire dampers to prove that they open and close properly.

3.05 CONTROL SYSTEMS ADJUSTING AND BALANCING:

A. In cooperation with the Mechanical Contractor, the Controls Contractor, and Engineer, set adjustment of controls to operate as specified.

B. Adjust and record set points of all control valves, dampers, controls and safeties for each equipment item, such as heat exchangers, pumps, fans, ductwork, valves, and the like, for each system. Coordinate with the Controls Contractor as required.

3.06 AIR HANDLING UNIT ADJUSTING AND BALANCING:

A. Take all balancing readings with filter pressure loss simulated for dirty filters to insure 100% air flow can be achieved with filters dirty. This shall be achieved by partially blocking off a portion of clean filter sections until the differential pressure across filters is equal to the scheduled dirty filter pressure loss.

B. Adjust fan and/or motor pulleys as required to achieve 100% design air flow with fan motor and variable speed drive operating at 100% speed.

3.07 SOUND AND VIBRATION:

A. Perform tests in accordance with ASHRAE guidelines for any equipment where objectionable noise is present. Use an ANSI type 1 or 2 sound level and meter to determine noise levels. Tests shall include readings at octive band levels for each location tested.

B. Measure vibration amplitude of all air handling units and all major rotating equipment.

C. Where excessive noise is caused by unbalanced or misaligned or improperly supported piping or equipment, the Mechanical Contractor shall correct such problems at no additional cost to the Owner.

D. Report equipment or rooms that appear to exhibit "out-of-range" or abnormal noise conditions.

E. Verify that vibration isolation components (hangers, spring supports, vibration pads, and the like) are properly installed, aligned and are not "bottomed-out" or short-circuited by improper contact. Document potential isolator problems for resolution by the Contractor.

3.08 TEST SCHEDULES:

A. General:

1. Provide the data required in Part 1 - General of this section. For each test, record the outside air temperature and humidity during the actual test. List the specified design data, first test reading taken, and final reading for each measurement.

2. Title/Cover Page:

a. Company name
b. Company address
c. Company telephone number
d. Project name
e. Project location
f. Project Architect
g. Project Engineer
h. Project Contractor

3. Instrument List:

a. Instrument
b. Manufacturer
c. Model
d. Serial number
e. Range
f. Calibration date

B. Air Handling Unit Data:

1. Designation, tag number

2. Manufacturer, model and serial number

3. Size

4. Motor hp, volts, cycles, phase, service factor and F.L. amps (nameplate)

5. Design conditions:

   a. Supply air flow, CFM
   b. Outside air flow, CFM (Minimum and Maximum)
   c. External Static Pressure, In. w.g.
   d. Fan RPM
   e. BHP

6. Field tests:

   a. Supply air flow, CFM
   b. Outside air flow, CFM
   c. Inlet Static Pressure, In. w.g. (at each section)
   d. Discharge Static Pressure, In. w.g. (at each section)
   e. Total External Static Pressure, In. w.g.
   f. Static Pressure at each unit section, In. w.g.
   g. Inlet and outlet air Temperature, Deg. F
   h. Fan RPM
   i. Volts/Amps (Each Phase)
   j. Calculated bhp

C. Coils:

1. Designation, tag number

2. Manufacturer, model and serial number

3. Size and type

4. Design conditions:

   a. Air Flow, CFM
   b. Face velocity, fpm
   c. Air Temperature, db/wb, in and out, Deg. F
   d. Air Pressure drop, In. w.g.
   e. Water flow rate, GPM
   f. Water temperature in, Deg. F
   g. Water temperature out, Deg. F
   h. Water pressure drop, Ft.
   i. Capacity, mbh

5. Field tests:

   a. Air Flow, CFM
   b. Face velocity, fpm
   c. Air Temperature, db/wb, in and out, Deg. F
   d. Air Pressure drop, In. w.g.
   e. Water flow rate, GPM
   f. Water temperature, in & out, Deg. F

g. Water pressure drop, Ft.
h. Calculated capacity, mbh

D. Air Balance Test Data:

1. Velocity tests for main and branch ducts and fresh air intake duct; exhaust terminals, and exhaust and supply ducts for all air handling units, packaged units, fans, and the like connected equipment and exhaust terminals:

   a. Duct location and designation
   b. Duct size
   c. Static pressure
   d. Duct average velocity, FPM
   e. Total air quantity, CFM

2. Individual diffusers, registers, and grilles:

   a. Diffuser, register, or grille identification as to location, area, and system
   b. Manufacturer, type and size
   c. Required and resultant test quantities, CFM
   d. Note any specific deficiencies or excessive noise

3. Duct accessories:

   a. Test fire dampers, smoke dampers, and combination fire and smoke dampers to prove that they open and close properly.

   b. Test control dampers to prove that they open and close properly, and verify all max. and min. settings.

E. Sound and Vibration Test Data:

1. Rotating equipment:

   a. Measure vibration amplitude (Peak-to-peak displacement in mils) in accordance with AABC test procedures. Fan wheels shall be both statically and dynamically balanced to provide for vibration displacement of bearing not to exceed the following measurements:

Shaft RPM	(Peak-to-Peak) Mils Displacement
600	2.0
900	1.5
1200	1.0
1800	0.75
3600	0.40

   b. Record dBA by octave band in 25% of the rooms (take readings approximately five feet above the floor on a line 45 degrees from the loudest noise source in the room)

c. List excessively noisy areas and study the situation along with the Engineer and Contractor.

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 – GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 INTENT: The intent of this Specification is to provide a quality installation which may not be attainable through the use of a standard composite consisting of insulation, vapor retarder and jacket assembled by an insulation manufacturer. However, in some installations, composites will be acceptable provided they meet the requirements of the Specifications relating to referenced standards for individual components.

1.03 STANDARDS: Insulation products and installation shall, as a minimum, comply with the National Commercial & Industrial Insulation Standards published by the Midwest Insulation Contractors Association (MICA), Omaha, Nebraska, latest edition.

1.04 DEFINITIONS:

A. All-Service-Jacket (ASJ): A white kraft paper bonded to aluminum foil and reinforced with glass fibers. The composite jacket has an integral longitudinal lap with woven glass fabric tape.

B. Concealed Spaces: All areas other than finished spaces which are generally not visible after completion of the project.

C. EPFI: Engineered polymer foam insulation.

D. Finishing Cement: A mixture of various insulating fibers, fillers, and binders with water, with or without hydraulic cement, to form a smooth trowelable paste insulation for application over insulating cement or unfinished block insulation.

E. Finished Spaces: All areas except pipe and duct tunnels, shafts and chases, and spaces above furred or dropped ceilings.

F. Foamed Plastic: Plastic expanded by thermal or chemical means, containing closed cells throughout.

G. Glass Fiber: A composite material consisting of glass fibers with a resin binder.

H. Mineral Wool: A generic term which applies to all types of inorganic fibrous insulations.

I. Perm: The measure of vapor transmission in grains of water through one square foot of a membrane in an hour at one inch mercury pressure difference.

J. PVC (Polyvinyl Chloride): A polymerized vinyl compound using chloride.

K. Rock Wool: A generic term which applies to all types of inorganic fibrous insulations. Also includes mineral wool products.

L. Sealer: A liquid coating used to prevent excessive absorption of finish coats

into porous surfaces.

M. Solvent Weld: A bonding method which uses a liquid solvent to dissolve one substance or material to form an adhesive base to permanently seal a joint; usually associated with PVC plastic materials.

N. Vapor Retarder (formerly Vapor Barrier): A membrane installed on the high vapor pressure side of an insulation material to prevent moisture penetration. A vapor retarder shall have a rating of 0.02 Perms or less.

O. Vapor Retarder Jacket: Any material or composite meeting the requirements of a vapor retarder and used for the finish of insulation material. It may be factory furnished or field applied.

1.05 ACCEPTABLE MANUFACTURERS shall be the following, referred to hereafter by abbreviation.

A. Insulation - Glass Fiber Blanket, Molded Pipe, and Board Type:

1. Certain-Teed Corporation, Insulation Group - (C/T)
2. Knauf Fiberglass - (KF)
3. Manville Product - (MP)
4. Owens/Corning - (O/C)

B. Insulation - Foamed Plastic Types:

1. Armacell
2. Rubatex

C. Insulation - Polyisocyanurate:

1. O/C

D. Insulation - Calcium Silicate:

1. MP
2. O/C
3. Pabco Insulation Division
4. Calsilite Insulation Products

E. Insulation - Cellular Glass Types:

1. Pittsburg Corning - (PC)

F. Vapor Barrier Jackets - Factory Applied:

1. C/T
2. KF
3. MP
4. O/C
5. PC

G. Metal Jackets - Aluminum and Stainless Steel:

1. Childers Products Co.

2. Pabco Insulation Division
3. RPR Products, Inc.

H. Mastics, Adhesives, Sealants, Coatings:

1. AWI
2. Foster Products
3. KF
4. C/T
5. MP
6. O/C
7. PC
8. Rubatex
9. Childers Products
10. VIMASCO
11. Mon-Eco

I. Insulated Fitting Covers and Jacketing - PVC Types:

1. C/T
2. KF
3. MP
4. Foster Products

J. Outdoor Jacket – Roof Membrane

1. Sarnafil

K. Fire Rated Duct Wrap

1. 3M
2. Firemaster

L. Substitutions: Under provisions of Section 23 00 10 - Mechanical General Provisions.

1.06 QUALITY ASSURANCE: The installing Contractor for the insulation systems specified in this section shall have been in continuous, uninterrupted stable business for a minimum of five (5) years in the installation of industrial and heavy commercial insulating systems.

1.07 QUALITY CONTROL:

A. All insulation shall be installed in a workmanlike manner by skilled workmen regularly engaged in this type of work.

B. Insulation shall be applied on clean, dry surfaces and only after tests and approvals required by the Specifications have been completed.

C. Insulation jackets shall be drawn tight, fitted smoothly, and wrinkle-free.

D. Do not use short pieces of insulation where a full length section will fit. Do not use damaged or crushed insulation products.

E. Do not insulate manholes, handholes, cleanouts, inspection stamps, and nameplates. Bevel, flash, and seal around insulation of adjacent surfaces. On

equipment operating at temperatures below dew point of the space, provide removable insulation covers for such items and clearly mark the surface of the insulation cover to identify the hidden appurtenance (nameplate, inspection stamp, and the like).

F. Insulation on all cold surfaces shall be applied with a continuous unbroken vapor retarder seal. Hangers, supports, anchors and the like that are secured directly to cold surfaces shall be insulated and vapor retarder sealed to prevent condensation. Continue insulation with vapor retarder through penetrations of walls, floors, and the like.

1.08 FIRE HAZARD RATINGS FOR INSULATION, fasteners, mastics, adhesives, and jacketing materials shall not exceed flame spread of 25, fuel contribution of 50 and when used indoors, smoke development of 50 as determined by ASTM E-84, E-87, NFPA 255, and UL 723 tunnel test ratings. Flameproofing and fireproofing treatments are not acceptable.

1.09 ASBESTOS of any type shall not be allowed in any materials used under this Section.

1.10 PROTECTION SADDLES for use at pipe hangers and supports shall be as specified in Section 23 05 29 - Hangers and Supports for HVAC Piping and Equipment.

1.11 SUBMITTALS are required on all insulation, as hereinafter specified, to include manufacturer's material data, thickness for each service, standards compliance and installation procedures. Each item shall be a standard catalog product of an established manufacturer and of equal quality, finish, performance, and durability to that specified. Submittals shall include project specification and the specific technical paragraph reference which specifies each item and other information necessary to establish contract compliance of each item to be furnished. Deviations from the specifications and performance data shall be clearly itemized on the Shop Drawing cover sheet with technical paragraph reference of all non-complying items or features. Partial or otherwise incomplete submittals will not be acceptable and will be returned without review. Refer to Section 23 00 10 for additional requirements.

1.12 MOCK-UP: Samples of insulation and insulation finish systems shall be submitted prior to start of any insulation work on this project. The mock-up samples shall demonstrate compliance with the Contract Documents, establish installation and workmanship standards, and provide a quality control benchmark for comparing installed systems with the mock-up samples. Each mock-up sample shall be clearly tagged to indicate pipe service/insulation system/jacket system for which it is being submitted. Insulation thickness applied to the mock-up sample shall be as specified in Section 23 20 12 - Piping Schedule. Mock-up samples may be prepared on site for review and approval, subject to Engineer’s agreement, and shall be furnished as follows:

A. Valve Insulation System Mock-Up Requirements: Submit one (1) valve insulation assembly mock-up sample for approval for each cold (chilled water, city water, etc.) piping insulation system scheduled. Mock-up samples shall show fabrication techniques for jacket closure systems around valve bodies, stems, actuators, and the like. Submittals shall include one sample of each typical cold service valve type that will be installed on the project. Construct valve assemblies with a minimum of six inches of insulated pipe extending from each side of the valve. Provide at least the following samples for approval:

1. Chilled Water - 4" butterfly valve assembly

2. City Water - 2" ball valve assembly

B. Insulation Insert Mock-Up Requirements: Submit one (1) insulation insert/shield assembly mock-up sample for approval for each cold (chilled water, city water, etc.) piping insulation system scheduled. Refer to Section 23 05 29 and details on the Drawings for requirements. Submittals shall include one sample for each typical cold service insert assembly that will be installed on the project. Mock-up samples shall show fabrication techniques for insulation system sealing and joining with insulation inserts, as well as jacket assembly at the insert. Construct insert assemblies with a minimum of six inches of insulated pipe extending from each side of the insert. Provide at least the following samples for approval:

1. Chilled Water - 4" hanger support
2. City Water - 2" hanger support
3. Steam – 3” hanger support

C. The insulation subcontractor shall coordinate with the Mechanical Contractor as required for pipe sections, valves, and accessories needed to construct the mock-up insulation samples.

D. Outdoor Insulation Mock-Up Requirements: Submit one (1) insulation mock-up sample for approval for ductwork to be installed outdoors. Submittals shall include one sample a representative sample including ductwork, insulation, jacket, supports, and fasteners that will be installed on the project. Construct mock-up with a minimum twenty four inches of duct length with support for approval.

1.13 ALTERNATE INSULATION MATERIALS: Substitutions for alternate insulation products, materials or assemblies shall be submitted as required in Section 23 00 10 - Mechanical General Provisions. Substitutions of alternative materials to improve quality, construction schedule or costs will be reviewed by the Owner's representative, provided the documentation required in Section 23 00 10 is furnished. In addition, submit a mock-up sample(s) of the assembled proposed insulation system(s). Submit cost change proposed for the alternate insulation materials for consideration by the Owner.

1.14 WHEN UNABLE TO PROVIDE LABELING as required, submit certificates from the manufacturer stating that materials meet specified requirements.

1.15 DELIVERY, STORAGE, HANDLING, AND PROTECTION: Comply with Section 23 00 10, Mechanical General Provisions.

1.16 WARRANTY: Comply with Section 23 00 10, Mechanical General Provisions.

PART 2 - PRODUCTS

2.01 MOLDED GLASS FIBER INSULATION: Pipes and Circular Ducts: ASTM C-547 preformed glass fiber insulation. Insulation shall be Class 1 or 2, rigid, non-combustible, one-piece pipe insulation with 850°F maximum service temperature, nominal "K" value of 0.23 at 75°F mean temperature, jacket permeance of 0.02 perms for ASJ facing. When specified for applications requiring a vapor retarder seal, furnish insulation with ASJ and self-sealing lap (SSL) joint on longitudinal seams.

Acceptable Products:

A. C/T CertaBlue Bond SSL or ASJ, as specified.
B. KF Pipe Insulation ASJ-SSL or ASJ, as specified.
C. MP Micro-Lok AP-T Plus or AP, as specified.
D. O/C Fiberglas Heavy Density Pipe Insulation ASJ/SSL-II or ASJ, as specified.

2.02 FOAMED PLASTIC INSULATION: Pipe, Ductwork, and Equipment: ASTM C-534 closed cell elastomeric thermal insulation. Insulation shall be Type I (tubular) or Type II (sheet), water vapor permeability of maximum 0.20 perm-in per ASTM E-96, "K" value of 0.28 at 75°F mean temperature, service temperature range of -40 to +220°F. Pipe insulation to 1" thickness and 2" sheet shall have a maximum flame spread rating of 25, smoke developed 50 per ASTM E-84.

Acceptable Products:

A. Armacell AP Armaflex Pipe/Sheet Insulation
B. Rubatex Pipe Insulation/Sheet Insulation

2.03 FLEXIBLE GLASS FIBER INSULATION: Ductwork, Equipment and Pipe Accessories: ASTM C-553 glass fiber blanket insulation (industrial type). Insulation shall be Type I/Class B-4, resilient, flexible blanket insulation with minimum density of 1.50 lb/cu.ft., 250°F insulation service temperature, "K" value 0.25 at 75°F mean temperature (at labeled thickness), and permeance of 0.02 perms for the FSK (aluminum foil-fiberglass scrim-laminated kraft) facing.

Acceptable Products:

A. C/T Duct Wrap
B. KF Duct Wrap
C. MP Microlite Duct Wrap
D. O/C All Service Duct Wrap

2.04 RIGID GLASS FIBER BOARD INSULATION: Ductwork and Equipment: ASTM C-612 glass fiber board insulation (industrial type). Insulation shall be Class 1, rigid, heavy density board insulation with minimum density of 3.0 lb/cu. ft., 450°F insulation service temperature, "K" value 0.23 at 75°F mean temperature, and permeance of 0.02 perms for the FSK facing.

Acceptable Products:

A. C/T Industrial Insulation Board (IB 600)
B. KF Insulation Board (6.0)
C. MP 800 Series Spin-Glas (#817)
D. O/C 700 Series Insulation (#705)

2.05 VAPOR RETARDER (VAPOR BARRIER) JACKETS

A. Premolded PVC Fitting Covers, Pipe Covers, and Accessories - Pipe:

1. PVC jackets and accessories shall be self-extinguishing type, flame spread 25, smoke developed 50 as tested per ASTM E-84. Products shall also comply with NFPA 90A and 90B.

2. PVC jackets and accessories shall have a service temperature range of 0 to 500°F (ambient temperature range of 0 to 150°F) and moisture transmission less than 0.05 perms.

3. PVC jackets and accessories shall be minimum 20 mil (0.020 inch) thick, suitable for use with solvent type welding adhesive. All jacketing materials shall have a smooth, high gloss (sanitary) finish, UV resistant. Color: White.

4. Adhesives, tapes, sealant, and solvent weld compounds shall be compatible with the jacketing materials and recommended for use by the manufacturer. Vapor retarder jackets applied to the insulation shall also be compatible with the PVC jacketing.

5. Furnish precut or field fabricated insulation inserts for all pipe fittings and accessories. Insulation inserts shall be constructed of insulation matching the service pipe insulation. Furnish PVC fitting covers for elbows, tees, flanges, and, when mechanical joints are scheduled, furnish fitting covers for mechanical joint (Victaulic) piping.

6. For piping and round ductwork applications, provide pre-curled jacket sections sized to yield a minimum one inch (1") overlap of the installed insulation assembly. Pre-curled jacketing shall be MP Zeston 2000 PVC Cut & Curled jacketing or approved equal.

7. Acceptable products, subject to compliance with this specification: MP Zeston 2000 PVC, Foster Speedline 25/50 Smoke-Safe, Accessible Products Company Type 800HD, or approved equal.

B. Kraft and Foil (ASJ) - Pipes and Equipment: Meet or exceed ASTM C-1136, NFPA 90A requirements, permanently flame retardant and U.L. listed. Outer ply - minimum 35 lb. white bleached embossed kraft. Inner ply - aluminum foil reinforced with fiberglass yarn 1/16" o.c. both directions. Ply bonding adhesive - flame extinguishing. Water vapor permeance 0.02 perms or less, -20 to +450°F service temperature. Plain joint laps for field applied adhesive or laps with pressure sensitive adhesive will be accepted. Acceptable products: MP type AP or AP-T Plus, O/C 25 ASJ, C/T ASJ, or KF ASJ or equal.

C. Foil-Scrim-Kraft (FSK) - Ductwork: Meet NFPA 90A requirements, permanently flame retardant and U.L. listed. Inner ply - minimum 40 lb. flame resistant paper. Outer ply - aluminum foil, ply bonding adhesive - flame extinguishing. Water vapor permeance 0.02 perms or less, 40 to 250°F service temperature. Acceptable products: MP type FSK, O/C FRK 25, C/T FSK, or KF FSK.

D. Saran Vapor Retarder Film – Meet or exceed NFPA 90A requirements, Water vapor permeance 0.03 perms or less, ASTM E84 flame spread and smoke developed rating of 25/50 or lower, minimum tensile strength of 20 lb/sq. in.

2.9 PROTECTIVE/FINISH JACKETS

A. Canvas - Pipes, Ducts and Equipment: (Field Applied) U.L. listed, plain-weave 100 percent cotton fabric with hard twisted yarns, impregnated with a dilute fire retardant lagging adhesive, minimum 8.0 oz/sq.yd. unless scheduled otherwise. Furnish a certificate of compliance letter from the manufacturer to verify that the products provided meet the specification.

B. Fiberglass - Pipes, Ducts and Equipment: (Field Applied) Industrial quality fiberglass fabric constructed of glass fiber materials with a density of 0.094 lbs/cu.in. and tensile strength of 500 lbs. at 70°F. Jacketing fabric shall have a minimum density of 14 oz/sq.yd. and be treated by the manufacturer to contain a water-activated adhesive for lagging applications. Fiberglass jackets shall be Glas-Tex fabric (Style 84215, Finish 9995) as manufactured by J.P. Stevens Company, or equal.

C. Metal - Aluminum - Pipes and Accessories: (Field Applied)

1. Metal jacketing shall be 0.016" thick aluminum or aluminum alloys conforming to ASTM B-209. Metal jacketing installed outdoors shall be furnished with a stucco embossed pattern and 3/16" deep circumferentially corrugated exterior surface. Metal jacketing installed indoors shall be smooth, non-corrugated type. All jacketing shall have an integrally bonded moisture barrier coating over the entire surface in contact with the insulation. The moisture barrier coating shall be composed of one layer of one mil thick polyethylene film with a protective layer of 40 pound kraft paper, or the equivalent, to prevent moisture and corrosives within the insulation from contacting the metal jacket and causing a galvanic or chemical corrosion.

2. Outdoor jacketing shall be equivalent to Corrolon Jacketing by Childers Products Company. Indoor jacketing shall be equivalent to Rolled Jacketing by Childers Products Company.

3. Fastening devices shall be Type T-304 stainless steel bands, 0.020" thick, 1/2" wide, equal to Fabstraps by Childers Products Company.

4. Metal fitting covers shall be 0.024" thick aluminum with a smooth or stucco embossed exterior finish, moisture barrier coating on interior surface, and interlocking weathertight joints. Secure metal fitting covers with all-aluminum fasteners, such as pop-rivets, as necessary to secure fitting covers in place. Pop-rivets with galvanized or carbon steel pins shall not be used. Fitting covers for 90 or 45 degree elbows shall be equal to ELL-JACS Elbow Insulation Covers by Childers Products Company.

5. Miscellaneous insulation covers for Flanges, Valves, Blind Flanges, Reducing Flanges, Concentric/Eccentric Reducers, and the like, shall be constructed of 0.020" aluminum. Tees shall be constructed of two matching halves of 0.024" aluminum. All aluminum components shall have an integral moisture barrier coating, and all such fittings shall be either factory fabricated units or skillfully crafted field fabricated insulation covers.

6. Seal all laps, seams, joints and raw edges of aluminum jackets installed on outdoor piping or where required for indoor piping jackets with caulking or sealant; Childers Chil-Byl CP-76, Foster 95-44, or clear silicone caulking (G.E. 1200, or equal).

D. Premolded PVC Fitting Covers, Pipe Covers, and Accessories - Pipe and Ductwork: (Refer to previous paragraph, Vapor Retarder Jackets.)

2.10 ADHESIVES (FIRE RESISTIVE)

A. Canvas Jackets: For securing field applied canvas jackets on insulation, with or without vapor retarder, lagging adhesive shall have a dry flame spread rating of 5 per ASTM E-162, 0 to 180°F service temperature, water vapor permeance of 1.3 perms, white color, tough, washable finish when dry; Childers Chil-Seal CP-50A Coating, Foster Sealfas 30-36, Mon-Eco 11-02, or Vimasco 713.

B. Flexible Glass Fiber Insulation: For securing field applied flexible glass fiber insulation to ductwork, pipes & equipment (other than internal duct liner insulation materials), adhesive shall have a dry flame spread rating of 5 per ASTM E-162, -20 to 180°F service temperature, fast drying synthetic elastomer adhesive designed to adhere fibrous glass insulation to sheet metal; Childers Chil-Stix Clear CP-85, Foster Stic-Safe 85-15, or Mon-Eco 22-05.

C. Foamed Plastic Insulation: For securing field applied foamed plastic insulation to ductwork, pipes and equipment, adhesive shall have a dried film flame spread rating not to exceed 25 per ASTM E-84 and smoke developed rating of 50, service temperature to 200°F for pipe and sheet applications, contact adhesive for joining seams, butt joints, and surface adhesion; Armstrong 520 Adhesive, Rubatex R-373 Adhesive, or equal.

2.11 SEALANTS AND ACCESSORIES

A. Sealants - Vapor Retarder Finish: For all interior field constructed vapor retarder finishes for equipment, fittings, valves, flanges, surface patches, joints, staple punctures, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, 20 to 180°F service temperature, water vapor permeance to 0.02 perms, white finish color, flexible, high build product suitable for use as a vapor retarder finish on pipe and block insulation and rigid thermal insulation. Vapor retarder finish coating shall be Foster Vapor Safe 30-80, or approved equal by Childers or Mon-Eco.

B. Sealants - Weather Barrier Finish: For all exterior field constructed weather barrier finishes for equipment, tanks, fittings, valves, flanges, surface patches, joints, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, -20 to +200°F service temperature, water vapor permeance to 1.0 perm (aged value), white finish color, tough, durable, thixotropic trowelable product for use as mechanical protection and weatherproofing of outdoor thermal insulations. Weather barrier finish coating shall be Childers Vi-Cryl CP-10/11, Foster Sealfas GPM 35-00, Mon-Eco 55-50, or Vimasco WC-1.

C. Sealants - Foamed Plastic Insulations: For all exterior applications and indoor applications where specifically called for to provide a protective or vapor retarder coating on equipment, tanks, piping, fittings, valves, flanges, ductwork, joints, lap edges, flashings and the like: Dry flame spread rating less than 5 per ASTM E-162, white finish color, resistant to ultra-violet effects, compatible with insulation and adhesives, tough, durable, weather-resistant finish. Sealants for foamed plastic insulation shall be Armstrong WB, Childers Vi-Cryl CP-10/11, or approved equal by Foster or Mon-Eco.

D. Sealants - Cellular Glass Insulations: For all applications where a vapor barrier joint sealant is specified on equipment, tanks, piping, fittings, valves, flanges, ductwork, joints, lap edges and the like: Moisture and vapor barrier joint sealant and bedding compound for rigid insulation, service temperature of -20 to 200°F, maximum 0.01 perm-inch water vapor transmission; Foster 30-46,

PC Pittcote 300, or insulation manufacturer's recommended sealant.

E. Reinforcing Mesh for Sealants: For all sealants specified or recommended by the manufacturer to be applied with a reinforcing mesh: High strength, open-weave pre-sized and resin treated fiberglass cloth, minimum 6x6 mesh (6 strands by 6 strands per square inch) conforming to ASTM D-1688 Type III, non-combustible, flexible, not subject to rot, mildew, or decay; Childers Chil-Glas #5 (or #10) or equal. Vimasco Elastafab 894 constructed of modacrylic fibers, or equal, is also acceptable.

F. Cements for Pipe and Equipment: ASTM C-449 blended mineral fibers and inorganic refractory materials, hydraulic setting binder, thermal insulating and finishing cement for applications to 1200°F. Product shall be trowelable over surfaces, valves, flanges, and irregular surfaces and be non-cracking and exhibit low-shrinkage. High temperature insulating cement shall be Pabco Pabcote One Coat Insulating Cement, Fibrex Superkote Cement, or equal by Power House.

G. Sealants - Miscellaneous Joints: ASTM C-920, Type S, NS, Class 25 construction sealant shall be non-toxic, weatherproof silicone sealant suitable for use in sealing construction joints, metal jacketing joints and seams, pipe hanger saddles, and the like. Sealant shall be General Electric Construction 1200 Series Silicon Sealant or approved equal. Color shall be translucent (clear) or white, as required to match adjacent material finishes.

H. Acoustical Sealants: Acoustical sealants for sealing around duct or piping penetrations of building construction materials shall be resilient, non-shrinking, non-hardening, non-drying, non-sag type sealant designed for interior use in sealing concealed construction joints. Apply acoustical sealant over a flexible, durable, non-absorptive, compressible rod stock (backer rod) of polyethylene foam, neoprene foam, or approved equal. Acoustical sealants shall be as manufactured by Tremco, U.S. Gypsum Co., Woodmont Products, or approved equal.

2.12 TAPE

A. Ductwork Insulation: For sealing FSK vapor retarder jackets on ductwork insulation, use 4” wide glass fabric tape imbedded in Foster 30-80 vapor barrier, fire resistant adhesive Do not use pressure sensitive tape.

B. Piping Insulation: For sealing ASJ vapor retarder jackets on piping insulation, use matching tape with a foil inner layer with acrylic adhesive, fiberglass scrim reinforcement imbedded between an outer layer of bleached white fire retardant kraft paper and the inner foil layer. Tape shall be nominal 3" width for pipe insulation applications up to 7-1/2" OD and nominal 4" width for pipe insulation over 7-1/2" OD, permanently flame retardant and U.L. rated, permeance rating of 0.02 perms, mold and mildew resistant.

C. Insulating Tape: For insulating short lengths of piping and fittings in congested or hard to reach areas, use an elastomeric insulation tape equal to Armaflex Insulation Tape, Rubatex R-180-FS Insulation Tape, or Halstead Insulation Tape. Tape shall be nominal 2" wide, self-stick adhesive backing, 1/8" thick, and suitable for use on pipe surfaces to 160°F. Use only in applications specifically approved by the Owner's representative.

2.13 OUTDOOR JACKET – ROOF MEMBRANE

A. Roof Membrane: For waterproofing ductwork outdoors, use thermoplastic PVC polymer membrane with integral polyester scrim reinforcement, off white exterior, heat weldable, Sarnafil S327 roof membrane. Membrane shall be o.045 inches minimum thickness, with 200 Lbf./in minimum breaking strength, 0.5% maximum linear dimensional change.

B. Roof Membrane Adhesive: For adhering membrane to clean and dry surfaces. Sarnacol 2121 water-based adhesive.

2.14 FIRE RATED DUCT WRAP: Ductwork: One layer wrap for grease ducts rated in accordance UL 1978 shall provide not less than the manufacturer's required thickness. Foil encapsulated mineral wool blanket shall provide a UL shaft enclosure rating of 2 hrs.

PART 3 – EXECUTION

3.1 INSPECT ALL SURFACES AND VERIFY that work of other trades requiring insulation has been completed and is ready to receive insulation. Specifically check for obvious defects such as leaking pipe or duct joints, broken fittings, hanger supports, and the like, that would result in damage to the completed insulation job, or that would adversely affect the execution and quality of the insulation systems as specified. Do not proceed with application of insulation until defects are corrected.

3.2 REMOVE ALL DIRT, SCALE, OIL, GREASE, or other extraneous loose material from surfaces to be insulated.

3.3 VERIFY that piping, ductwork, equipment, vessels and the like have been tested in accordance with the Specifications prior to applying insulation materials.

3.4 INSTALL SPECIFIED MATERIALS either as sequentially applied components or as a composite system if applicable. Follow manufacturer's installation guides and instructions.

3.5 PIPE AND EQUIPMENT INSULATION

A. Molded Glass Fiber Insulation: Apply thickness shown in insulation schedule.

1. Sectional and segmental jacketed pipe insulation shall be applied so that ends of adjacent sections are butted tightly against each other. Sections of pipe furnished with all service jacket shall be securely taped in place on all longitudinal seams and circumferential joints. Sections of pipe furnished with all service jacket with self-sealing lap shall have the integral lap seam secured and all circumferential joints securely taped. Tape shall match the pipe insulation jacket.

2. Sectional and segmental unfaced pipe insulation shall be applied so that ends of adjacent sections are butted tightly against each other. Sections shall be securely wired or banded in place using not less than three ties of wire or two bands every eight inches (8") on center for each 3 ft. section on pipe sizes up to and including 6" size. For larger pipes, use two bands every eight inches (8") on center per 3 ft. section.

Wires shall be drawn taut to embed them flush with the insulation, firmly twisted, excess clipped and ends bent over and fully embedded into the insulation prior to application of finish jacketing.

3. Flanges, Strainers, Automatic and Manual Valves and Bonnets: Cover with plain duct wrap of 1.5 lb/cu. ft. minimum density, wrapped firmly under compression, and wired in place. Finish with 1/4 inch layer of hydraulic insulating cement to a thickness equal to adjoining insulation.

4. Fastening: Secure insulation jacket with lagging adhesive (Childers CP-50A or Foster 30-36) if not provided with self-sealing pressure-sensitive adhesive. In areas not accessible after construction, also secure insulation with aluminum bands on 12 to 18 inch centers.

5. Cover fittings (standard or Victaulic type) with one piece PVC premolded fitting covers stapled or tacked in place. Apply over proper shape factory precut insulation blanket. Before applying fitting cover on piping requiring a vapor barrier, apply two vapor barrier mastic beads 1/8" in diameter around pipe covering close to end of covering before applying PVC cover. Wrap circumferential edges of cover with vapor-barrier pressure sensitive color matching tape. Overlap tape 2 inches on adjacent insulation and on cover.

B. Foamed Plastic Insulation: Apply thickness shown in insulation schedule.

1. Piping Applications:

a. Unslit tubular insulation shall be slipped onto piping before it is connected.

b. Preslit tubular insulation shall be rolled onto piping after fabrication.

c. Tightly butt adjacent sections and seal with a contact adhesive specifically approved by the insulation manufacturer (Armstrong 520, Rubatex R-373, or equal). Fabricate fitting covers from miter cut tubular insulation using over-sized insulation segments lapped over adjacent sections. Do not stretch insulation to fit; use proper lengths of materials.

d. Unless scheduled otherwise, indoor applications will not require protective finish coats. Provide high density insulation inserts (calcium silicate or compressed glass) at the hanger support and the pipe to prevent compressing the foamed plastic insulation at pipe hangers. Thoroughly seal all joints at the insulation inserts. When protective or weather barrier finishes are specified, apply a single layer of reinforcing fiberglass cloth fully adhered to the surface. Apply two finish coats of sealant specified for foamed plastic insulations. Adhesives and sealants shall be compatible and approved for use on foamed plastics.

2. Ductwork and Equipment Applications:

a. Tightly butt adjacent sections and seal with a contact adhesive specifically approved by the insulation manufacturer (Armstrong

520, Rubatex R-373, or equal). Make all cuts square and apply with smooth skin surface facing out. Do not stretch sheets to fit; cut a new piece for proper fit.

b. Unless scheduled otherwise, indoor applications will not require protective finish coats. When protective or weather barrier finishes are specified and for all outdoor installations of foamed plastic insulations, apply a single layer of reinforcing fiberglass cloth fully adhered to the surface. Apply two coats of sealant specified for foamed plastic insulations. Adhesives and sealants shall be compatible and approved for use on foamed plastics.

C. Calcium Silicate Insulation: Apply thickness shown in insulation schedule.

1. Tightly butt edges, half-sections and break joints. Secure with wire for small areas, and aluminum bands 12" o.c. for large areas. Where required, provide welded studs, clips or angles as anchors for wires and bands.

2. Cover valves, bonnets, flanges, and fittings with molded calcium silicate fitting insulation where commercially available.

3. Cover valves, bonnets, flanges, and fittings with fabricated, mitered segments of molded calcium silicate of same thickness as insulation on adjacent pipe, wired in place. Finish with 1/4" thickness of hydraulic insulating and finishing cement.

4. Fittings on pipe sized 1-1/2" and smaller may be insulated with hydraulic insulating and finishing cement of same thickness as pipe insulation.

5. Cover equipment with fabricated, mitered segments of molded calcium silicate of same thickness as insulation on adjacent pipe, wired in place. Finish with 1/2" thickness of hydraulic insulating and finishing cement, with metal corner beads.

6. Cover equipment removable heads with 20 gage galvanized steel cover over insulation.

7. Where no additional finish is specified, apply 16 gage nickel copper alloy wire, 16 gage copper clad steel wire, or 16 gage stainless steel wire on 4" centers up to 6" pipe and 6" centers on pipe over 6" diameter.

8. Block insulation greater than 2" thick shall be applied in layers not exceeding 1-1/2" thick. All joints shall be staggered. Secure with wire. Cover with 1/2" thick hydraulic insulating and finishing cement. Protect all corners with metal corner beads.

D. Polyisocyanurate Insulation: Apply thickness and density shown in insulation schedule.

1. Apply single layer, half-sections of insulation to pipe and fittings. Provide fabricated coverings suitable for use on valves, pipe fittings, and steam and hydronic specialties, for proper fit. Tightly butt edges and seal all joints full depth with manufacturer's sealant. Do not use sealant

to fill voids or cracks. Check for tight seal at all joints and edges and reapply sealant as necessary. Do not use broken or cracked insulation products.

2. Secure insulation to piping with factory applied Saran jacket with self sealing lap in accordance with the manufacturer's recommendations. Provide a minimum two inch overlap of jacket at all joints, both circumferential and longitudinal. Jacket shall be thoroughly sealed to form a vapor retarder seal over the entire insulation assembly.

3. Cover Saran jacket with canvas to secure and protect. Fittings shall be covered with approved PVC jacketing over the specified insulation and shall be completely vapor retarder sealed.

4. Verify that all sealants, mastics, and the like are compatible for use on the specified insulation systems. Allow adequate curing time for all sealants and mastics prior to covering with insulation finish systems.

5. Inspect all insulation and accessory materials to be certain that the installation is in conformance with the manufacturer's recommendations and the requirements of referenced ASTM standards and this Specification Section. All joints shall be tight with complete sealing for vapor retarder. Exterior finish shall be uniform, free of defects, and installed in a neat workmanlike manner.

E.

3.6 DUCTWORK AND EQUIPMENT INSULATION

A. Rigid Glass Fiber Board: Apply thickness shown in ductwork schedule.

1. Cut insulation to fit between standing seams and stiffeners. Secure to metal with welded pins and self-locking caps installed flush with adjacent insulation surface. Pins shall be spotted 18" o.c. with not less than two rows of pins per side and with one pin spaced 3 inches in from each corner. Apply a heavy bead of vapor barrier sealant around each weld pin before installing cap. Caps shall match color of glass cloth jacket if used.

2. Cover fittings with material of same type and thickness. Score as necessary for curved surfaces.

3. Vapor retarders for FSK faced insulation shall overlap a minimum of 2" at all seams and be sealed with woven glass fabric tape with mastic. All penetrations, facing damage, and mechanical fasteners shall be covered with a minimum 2" overlap of tape or mastic.

4. Where scheduled, cover with finish jacketing of PVC or canvas.

3.7 CEMENTS, INSULATING AND FINISHING: Unless specified to the contrary elsewhere, provide a finished thickness of 1/2". Apply in two layers, reinforcing with No. 16 AWG 1" mesh galvanized wire netting. Trowel to a smooth hard finish. Install metal corner beads at all corners.

3.8 FIRE RETARDANT VAPOR RETARDER JACKETS FOR PIPE AND EQUIPMENT (ASJ)

A. Apply adhesive and jacket over insulation. Seal lap with field applied adhesive or factory applied pressure sensitive lap adhesive.

B. Apply sealant to fittings, valves, flanges and similar items. Vapor seal these items by embedding reinforcing mesh (fiber glass fabric) between two 1/16" thick coats of adhesive. Lap seal fabric 1 to 2 inches on itself and 2 inches on adjoining insulation.

C. Apply flashing on pipe, ductwork and equipment for a complete moisture and vapor seal at all metal-to-insulation joints, exposed edges of insulation and other protrusions through jackets, including staples and other fasteners. Apply a continuous bead or fillet of flashing sealant to completely seal the joint. Extend a 1/16" film of flashing sealant over adjacent insulation and metal surfaces at least 3". Embed glass fabric into the wet coating over entire surface, smoothing out all wrinkles. Immediately apply a 1/8" film of flashing sealant to the entire membrane surface leaving a large bead or fillet over the joint. All sealant shall dry, then extend adjacent finish over the flashing a minimum of 3 inches.

3.9 FIRE RETARDANT VAPOR RETARDER JACKETS FOR DUCTWORK, EQUIPMENT AND PIPE (FSK)

A. Apply Foil-Scrim-Kraft with adhesive over glass fiber insulation unless Foil-Scrim-Kraft is furnished integrally with the flexible or rigid insulation. Apply fire resistive adhesive sealant to full surface of laps and secure them with staples applied 6" o.c. Vapor seal all lap edges, jacket breaks, penetrations and staples with woven glass fabric tape with integral or field applied full coverage coating of fire resistive adhesive. Lap tape not less than 1 inch on itself and adjacent insulation. Finish shall be wrinkle-free. Cover breaks and penetrations with 3 inch width strip of glass fabric embedded between two 1/16" coats of vapor retarder sealant, lapping fabric not less than one inch on adjacent insulation.

B. Apply flashing on pipe, ductwork and equipment for a complete moisture and vapor seal at all metal-to-insulation joints, exposed edges of insulation and other protrusions through jackets, including staples and other fasteners. Apply a continuous bead or fillet of flashing sealant to completely seal the joint. Extend a 1/16" film of flashing sealant over adjacent insulation and metal surfaces at least 3". Embed glass fabric into the wet coating over entire surface, smoothing out all wrinkles. Immediately apply a 1/8" film of flashing sealant to the entire membrane surface leaving a large bead or fillet over the joint. All sealant shall dry, then extend adjacent finish over the flashing a minimum of 3 inches.

3.10 CANVAS JACKET: Cover entire insulation surface with canvas embedded between two 1/8" thick layers of lagging adhesive. Where canvas jacket is specified on cold surfaces and otherwise scheduled, embed canvas between two 1/8” thick layers of high build vapor retarder sealant. Overlap canvas at least 2" on itself and adjoining surfaces. Provide premolded PVC fitting covers for all insulated fittings, valves, and the like installed on systems scheduled to receive canvas jackets. PVC fitting covers shall be as specified elsewhere in this section.

3.11 FIBERGLASS JACKET: Cover entire insulation surface with fiberglass jacket between two 1/8" thick layers of lagging adhesive, liberally applied. Overlap fiberglass jacket at

least 2" on itself and adjoining surfaces. When applied on chilled water pipe insulation systems, provide a continuous vapor seal and smooth exterior finish. PVC fitting covers shall be as specified elsewhere in this section.

3.12 METAL JACKET: Cover entire insulation surface of piping with aluminum jacket and fitting covers. Locate longitudinal joints along the side of horizontal piping, with a minimum 1" wide overlapped joint positioned to shed water. Overlap circumferential joints 2" minimum. Seal all longitudinal joints and circumferential joints with vapor barrier sealant. Secure jacket in place with stainless steel bands on 10" maximum center-to-center spacing. Use a minimum of 3 stainless steel bands on each fitting cover. Pop rivets and/or screws shall not be used on metal jacketing.

3.13 PVC JACKET: Cover entire insulation system in designated areas with a 20 mil thick PVC jacket. Jacketing system shall be continuous to cover all straight lengths of pipe and fittings, flanges, valves and pipe terminations, and ductwork systems when scheduled for PVC jacket. All lap joints (longitudinal and circumferential) in the jacketing system shall be permanently sealed with a solvent weld type adhesive equal to M/P Zeston PermaWeld. All pipe fittings shall be insulated by applying the proper size and type of precut insulation insert to the pipe fitting prior to installing the PVC fitting cover. Install PVC fitting cover in accordance with manufacturer's recommendations to ensure good adhesion. Apply the PVC jacketing over the pipe insulation and overlap the fitting cover by approximately one inch and apply the manufacturer's solvent adhesive to all circumferential and longitudinal joints and overlaps. Inspect all seams and overlaps and touch-up with adhesive as required. Domestic and chilled water piping and ductwork systems shall have a vapor retarder jacket applied prior to installing the PVC jacket, unless scheduled otherwise. High temperature systems shall be installed with appropriately spaced slip-joints in the PVC jacket as per the manufacturer's recommendations.

3.14 INSULATION SCHEDULE (See Also Drawings)

A. General: Specific details and notes in this schedule shall take precedence over other paragraphs of this Specification Section 23 07 00. For example, if the product specification in Part 2 above calls for 1.5 pounds per cubic foot minimum density, and this schedule calls for 3.0 pounds per cubic foot (PCF), then the scheduled 3.0 PCF applies to this job.

B. Ductwork: Duct insulation shall be as scheduled in Section 23 31 15 - Ductwork Schedule - Service and Material Systems.

END OF SECTION

SECTION 23 09 00
INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 SCOPE OF WORK - OVERVIEW:

A. It is intended that the Facility Management System (FMS) Control and Instrumentation work shall be a subcontract to the Mechanical Contractor. Where the Specification refers to the Controls Contractor, it shall be understood that the Controls Contractor is a subcontractor to the Mechanical Contractor.

B. Furnish and install a complete electronic Building Automation System for the HVAC system, including all control accessories, hardware, software, and devices necessary to execute the sequence of operation.

C. All control wiring, devices, and components shall be new. No existing valves, sensors, actuators, transmitters, or components may be reused.

D. These Specifications, together with the information shown on the Drawings, define the automatic control of all equipment described under "Sequence of Operation". The automatic temperature control system includes, but is not limited to, temperature transmitters, controllers, automatic dampers and valves, damper operators, switches, control panels and other accessory equipment and devices along with a complete system of control, pneumatic tubing, and electrical wiring to fulfill the intent of these Specifications and to provide for a complete and operable system.

E. The system shall be installed, started-up, and serviced by factory trained mechanics and system specialists regularly employed by the manufacturer of the control equipment.

F. The system vendor shall have an operating branch office within 100 miles of the job site, and shall show proof of this branch office providing engineering, installation, start-up, on-going support and services for the proposed type system for the past 10 years.

G. Contractors shall note that the requirements of this section are specific and describe in detail the exact components and system capabilities necessary for the optimum operation of the facility's HVAC equipment. All requirements will be strictly interpreted and enforced by the Engineer and his representative. Failure to comply with any provision may result in rejection of submittals and/or default.

H. The Mechanical Contractor shall include in his bid all work required by the Mechanical Contractor in this section, such as the installation of control valves and dampers, sensors and the like.

I. The above overview is general and is not all-inclusive. Refer to the

Specifications and Drawings for the complete work required.

1.03 GENERAL:

A. Include all labor, materials and appliances required for furnishing, installing testing, adjusting and placing in operation all control and instrumentation work shown on the Drawings and specified herein, complete and satisfactory to the Owner's representative.

B. The Controls Contractor shall furnish and install all equipment, accessories, electrical control and interlock wiring and instrument piping required for complete and functioning control system except as described under "Work by Others" in Part 3 of this Section.

C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems, and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use. No used or existing control equipment will be permitted in the new control system.

D. The DDC (Direct Digital Control) System shall be of a fully modular architecture, permitting expansion by adding computer memory, application software, operator peripherals and field hardware.

E. Tie-ins are required into Mechanical Contractor furnished equipment. The Controls Contractor shall coordinate.

F. The Controls Contractor shall provide a permanently assigned engineering and construction coordinator that is experienced in coordination and directing work of the magnitude and complexity of this project. The Controls Contractor shall submit for review and acceptance by the Engineer prior to commencing the work, the name of the proposed coordinator to be assigned to this project. This coordinator shall be assigned to this project until final site visitation unless otherwise released by the Engineer.

H. The Controls Contractor shall provide Local Area Network connection at each specified panel location so that future panels may be connected. Software shall provide for overall points to be added without any additional software cost to the Owner.

I. The Controls Contractor must provide the labor to design the graphics displays for all the new systems on all of the existing graphical workstations.

1.04 WORK BY OTHERS:

A. Automatic control valves and separable wells for immersion elements shall be furnished by the Controls Contractor and shall be installed by the Mechanical Contractor under this contractor's supervision. The Mechanical Contractor shall provide and install pressure taps, isolation valves and other couplings required by any pressure and/or flow instrumentation specified below.

B. Automatic (control and smoke) dampers shall be furnished and installed by the Mechanical Contractor under this Contractor's supervision. It shall be the responsibility of the Mechanical Contractor to see that the dampers are

correctly installed so that they operate freely and close tightly. It shall be the responsibility of the Mechanical Contractor to provide and install transitions when the control application requires dampers smaller than duct size. It shall be the responsibility of the Mechanical Contractor to provide and install round or oval to rectangular transitions when the control application requires dampers in oval or round duct.

C. The Mechanical Contractor shall install, in a neat and professional manner, all air flow measuring stations. He shall take great care to follow the manufacturer's instructions. Where transitions are required, he shall furnish 15 degree transitions so as to minimize the air disturbance. Access doors shall be furnished and installed by the Mechanical Contractor to allow access to the flow station sensing grid.

D. All finish painting required for building management and control equipment shall be done by the Mechanical Contractor.

E. All cutting and patching necessary for the installation of the Building Management and Control System shall be done by the Mechanical Contractor at the expense of this Contractor.

F. Refer to Section 23 00 10 for complete details of Mechanical, Electrical, and Controls work coordination.

1.05 REFERENCED STANDARDS, CODES, AND ORDINANCES:

A. It is the responsibility of the Controls Contractor to be familiar with all codes, rules, ordinances, and regulations of the authority having jurisdiction and their interpretations which are in effect at the site of the work.

B. The latest issue of applicable standards and recommended practices of the following agencies in effect shall form a part of the specification to the extent each agency's relative standards or recommended practices apply to the systems and their components as specified herein.

1. Federal Communications Commission (FCC)
2. American National Standards Institute (ANSI)
3. American Society of Mechanical Engineers (ASME)
4. Electronic Industries Association (EIA)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA)
8. Underwriters Laboratories (UL)
9. Occupational Safety and Health Administration (OSHA)
10. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

C. The Controls Contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and using industry accepted installation procedures required for the work as outlined in these documents.

D. All systems' equipment, components, accessories, and installation hardware shall be new and free from defects and shall be in accordance with the National

Electric Code and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All systems' components of a given type shall be the product of the same manufacturer.

E. The Controls manufacturer shall have ISO 9002 certification for all controls products used. Proof of such certification shall be supplied to the Engineer for approval prior to acceptance.

1.06 INTENT OF SPECIFICATIONS AND DRAWINGS:

A. It shall be understood that the Drawings and Specifications describe the approximate locations of the work. Do not scale the Drawings to determine exact positions and clearances. Obtain from the Engineer any dimensions not shown.

B. Bring to the attention of the Engineer, immediately, any changes in the size or location of the material or equipment which may be necessary in order to meet field conditions, or in order to avoid conflict with the equipment of other sections. Obtain the Engineer's approval before such deviations are made.

C. Details of construction and of workmanship, where not specifically described herein or indicated on the Drawings, shall be subject to the Engineer's approval.

D. Obtain from the Engineer at the site the location of any apparatus not definitely located on the Drawings. Locate equipment and accessories in such a manner as to provide easy access for proper service and maintenance. Special care is required to provide accessibility to openings in equipment requiring maintenance. Bring to the attention of the Engineer any condition which prevents adequate accessibility for maintenance, prior to installation of that work.

E. Before submitting proposals, examine the Specifications and Drawings relating to the work and become fully informed as to the extent and character of the work and the relation of the work to that of other sections. Examine the Drawings of other sections to become familiar with all the possible problems and details of the building construction which affect the work.

1.07 SHOP DRAWINGS:

A. Submittals shall comply completely with Section 23 00 10, Mechanical General Requirements.

B. Submit for review by the Owner's representative, prior to purchase or installation of equipment, shop drawings of all major equipment and all specially constructed equipment proposed for use in the project. Submittals shall consist of manufacturer's scale drawings, cuts or catalogs, including descriptive literature which shall indicate the construction, material, physical dimensions and complete operating data. All automatic controls shop drawings shall contain a verbal description of the sequence of operations, enumerating and describing the function of each component.

C. Provide complete catalog cuts, engineering data and other applicable information on all items of equipment. Submittals shall include product bulletins, engineering manuals, application manuals, installation manuals, and commissioning/troubleshooting manuals for all devices.

D. The following submittals are required:

1. System architecture showing all digital devices
2. Detailed points list indicating points to be graphically displayed, including adjustment, alarms, and trends
3. Detailed color conventions for all graphics and graphic elements
4. Valves, actuators, and accessories
5. Dampers, actuators, and accessories
6. Control and wiring diagrams of controlled mechanical systems
7. Control unit panels, point layouts, and addresses
8. Sarter and interlock wiring diagrams
9. Squences of operation
10. Material lists with part numbers, quantities and descriptions
11. Technical data sheets for each piece of equipment
12. As-built drawings with interconnecting wiring diagrams or wire lists of the complete field installed system with complete, properly identified ordering numbers of each system component and device.
13. Operator's manual(s) with pictures and step-by-step operating procedures. This manual shall be indexed and shall have a separate tabbed section for each operator function.
14. Trunk cable schematic showing remote unit locations and all trunk data conductors.

1.08 SYSTEM COMMISSIONING:

A. After equipment and control system start-up is complete, verify all graphics are complete and loaded prior to system commissioning and coordinate with Commissioning Agent.

B. Provide assistance during commissioning as required to complete the commissioning procedures.

1.09 SYSTEM ACCEPTANCE:

A. Submittal data relevant to point index, functions, sequences, interlocks, and associated parameters, and other pertinent information for the operating system and data base shall be forwarded from the Contractor to the Owner. Prior to full operation, a complete demonstration of the system operation shall be performed in the presence of the Owner and the Engineer. This demonstration, having satisfactorily met previously approved submittals, shall, with the Owner's written acceptance, allow commissioning of the system. Upon successful completion of system operation, the Owner and Engineer shall be requested, in writing, to inspect and approve the satisfactory operation of the system, sub-systems, and accessories. Upon completion of the installation, the System contractor shall start up the system and perform all necessary testing and debugging operations. An acceptance test in the presence of the Owner's representative, the Architect, and the Engineer shall be performed. When the system performance is deemed satisfactory in whole or in part by the

observers, the system parts will be accepted for beneficial use and placed under warranty.

B. Problems which occur within approved hardware or software shall be corrected in an appropriate fashion under warranty. Any such occurrence shall not void previous approval; however, the System Contractor shall be responsible to attend to and remedy such items within the warranty period. Appropriate logs, schedules and reports shall be maintained to reflect these items and their redress.

1.10 OWNER'S INSTRUCTION: The System Contractor shall provide four bound copies and an electronic copy of an operator's manual describing all operating and routine maintenance service procedures to be used with the system. The system contractor shall instruct the Owner's designated representatives in these procedures during the start-up and test period and commissioning phase. This instruction shall be conducted during normal working hours.

1.11 SHIPPING TAG: Each component shall be tagged at the factory with its specific location on the job, including AHU designation, building floor, room/area served, and the unit designation shown on the Drawing.

1.12 NAMEPLATES: Provide nameplate on each component as required by Section 23 05 53 - Mechanical Identification.

1.13 WARRANTY:

A. The control system herein specified shall be free from defects in material and workmanship under normal use and service for a period of twelve (12) months after final inspection and acceptance by the Owner, under the provisions of Section 23 00 10.

B. If within the twelve (12) month period, any equipment, software, or labor is found to be defective in workmanship or materials, it shall be replaced or corrected free of charge by the FMS Controls Contractor.

C. Factory authorized warranty service shall be required within 100 miles of jobsite, 24 hours per day, 7 days per week.

PART 2 - PRODUCTS

2.01 MANUFACTURER:

A. The control system shall be furnished and installed by Johnson Controls, Trane, or Alerton. Bids by suppliers other than those listed are not acceptable.

B. The Control Contractors listed above shall submit a "Line-by-Line" description to the Engineer detailing where their system does not meet the Specification. Failure to submit this description signifies that the product proposed will comply with the Specification in product and performance. If it is discovered that the installed system does not comply with the Specification in the period before the warranty period is complete, the system shall be removed and the specified system shall be installed. The cost for this new system and the cost for delays shall be by the vendor and his contractors.

2.02 SYSTEM AND CONTROL CONCEPT:

A. Overview:

1. Information is provided in this Specification Section for a complete distributed DDC system.

2. This Specification also defines the requirements for Direct Digital Control (DDC) systems that are equipped to interface with the Owner's monitoring and control system and both analog and binary inputs/outputs on a "stand-alone" basis. The objective of this control concept is to provide a control system with a maximum level of flexibility and reliability by distributing control requirements over a network of small microprocessor-based control modules. The system shall perform enhanced control operations to minimize energy consumption.

B. System Concept:

1. The Integration Platform shall include, but not be limited to, the following components/sub systems to provide a fully functional platform required for integrating building systems:
   a. Niagara Web Supervisor
   b. Niagara Workbench
   c. Associated Niagara drivers and applications
   d. Niagara based hardware platforms (JACE)
   e. Installation, engineering, programming. commissioning

2. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.

3. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS.

4. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any designated computer on the owner's LAN.

5. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.

6. The integration platform server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the Niagara 4 Framework server.

7. A laptop computer shall be provided by the owner for installation of engineering/programming software (Niagara 4 Workbench).

8. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the

following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". In any case, the end user shall maintain the right to instruct the contractor to modify any software license, regardless of supplier, as desired by the end user. The contractor shall not install any "brand-specific" software, applications or utilities on Niagara Framework-based devices. All hardware and field-level devices installed shall not be limited in their ability to communicate with a specific brand of Niagara Framework JACE. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed, in replacement of or in parallel with existing components. All controllers must be able to be programmed within the Niagara Workbench. At the completion of the project, the owner shall be given all existing platform and station login credentials to include; super user (admin) user names; passwords and passphrases.

9. All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.

2.03 HARDWARE:

A. JAVA APPLICATION CONTROL ENGINE JACE-8000 and EDGE-10:

1. The FMCS shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. The JACE shall connect to the owner's local network, wide area network, or operational technology network (OTN) depending on configuration. Each JACE is capable of communicating to LonMark/LonTalk (IDC) and/or BACnet (IBC) controllers and other open and legacy protocol systems/devices.

2. The JACE shall be model JACE-8000 (JACE-8000) EDGE -10 (VEC-10) with corresponding IO and Communications modules.

B. Sensors and Field-Mounted Devices:

1. Temperature Sensors:

a. Temperature sensors shall use platinum elements where resistance increases with temperature in a known and repeatable manner.

b. All sensors of a particular category shall be of the same type and manufacturer. Provide temperature sensors suitable for one or more of the following mounting methods:

(1) Room Type - Suitable for wall mounting with mounting bracket, wallplate adapter, element holder and cover enclosure.

(2) Insertion Type - Suitable for insertion into air ducts at any angle with element holder and cover enclosure.

(3) Immersion Type - Suitable for immersion into fluids in tanks or pipes with separable immersion well, sealant, spacer, adapter, handi-box, and heat transfer compound.

(4) Averaging Type with Extended Element - Suitable for duct mounting to obtain average temperature by sampling along a capillary tube element not less than 10 ft. in length.

(5) Outside Air Sensing Type - Suitable for outdoor location with metal housing and located to minimize building outside air film effects.

c. Temperature sensor specifications shall comply with the following performance criteria:

Temperature Elements	Nickel RTD
Sensor Accuracy	$\pm$ 0.34°F @ 70°F
Reference Resistance	1000 ohms @ 32°F
Temperature Range	-50 to 275°F

2. Humidity Sensors: Thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degree F. Duct mounted type sensors shall have a stainless steel insertion element, sealed to prohibit corrosion. Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

3. Carbon Dioxide Sensor:

a. The carbon dioxide sensor shall be wall mounted near return inlets and determine concentration of CO_2 by measuring the attenuation of a specific wavelength of infrared light as the light travels from its source to a detector along a defined optical path.

b. Device specifications shall comply with the following:

Measurement range	0 to 2000 ppm CO_2
Accuracy	+100 ppm CO_2
Repeatability	+20 ppm CO_2
Drift	+100 ppm CO_2 per year
Output signal	0 to 10 VDC proportional over the 0 to 2000 ppm CO_2 range
Accessories	Single-point calibration kit, filter

4. Line Voltage Thermostats:

a. Line voltage or control voltage thermostats for ventilation fans, unit heaters, and the like shall be Penn Model A19-B coiled bulb type, with single-pole double-throw contact mechanism 30° to 120° range, 16 amp rated, and adjustable deadband.

b. Line voltage thermostats shall be provided by the Controls Contractor as detailed on the individual control diagrams.

5. Differential Air Pressure Switch: Differential pressure switches for proving fan operation or sensing dirty air filters shall be SPDT type, UL approved, and selected for the appropriate operating range of the equipment to which it is applied. Sensor shall have 1/4" compression type fittings and shall have an adjustable setpoint. Furnish with 1/4" barbed type static pressure tips.

6. Differential Pressure Transmitters: For sensing the differential pressure in a distributed piping system, furnish a self-contained type differential pressure transmitter, 4 - 20mA output, accuracy of plus or minus 0.25 % of calibrated span, and -40 to +220 degree F operating temperature limits. Design range shall be as required for the system.

7. Current Switches: For proving fan or pump operational status, provide solid or split-core type current status switches with adjustable setpoint and solid state internal circuitry. Current switch shall have induced power, trip point set adjustment to plus or minus 1% over a range of 1 to 135 amps, trip and power LED, and field adjustable to indicate both On-Off conditions and loss of load (broken belt, etc.). Units shall have a five year warranty. Current switches shall be Hawkeye Series by Veris Industries, or approved equal.

8. Output Devices:

    a. Control Relays: Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contacts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices.

    b. Reed Relays: Reed relays shall be encapsulated in a glass-type dust tight enclosure and plugged into a plastic or epoxy case. Contacts shall be rated for 150% of the loading applications. Operating and release time shall be one millisecond or less. Reed relays shall have a minimum life span rating of 10 million operations and shall be equipped with coil transient suppression devices.

    c. Solid State Relays (SSR): Input/output isolation shall be greater than 10 billion ohms with a breakdown voltage of 15 V root mean square, or greater, at 60 Hz. The contact operating life shall be 10 million operations or greater. The ambient temperature range of SSRs shall be 20^{o}F - 140^{o}F. Input impedance shall be greater than 500 ohms. Relays shall be rated for the application. Operating and release time shall be 10 milliseconds or less. Transient suppression shall be provided as in integral part of the relays.

9. Dampers:

    a. Control dampers for HVAC systems shall be provided to allow effective modulation or close-off of air flow as required for each

fan system. Damper frames shall be constructed to facilitate field assembly of several individual sections into larger damper area and shall be provided with openings or mounting clips to allow secure fastening of damper frame to the surrounding ductwork, collar, or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided with suitable bearings for smooth operation and all blades shall be interconnected to provide unison operation.

b. Dampers shall be provided with either parallel or opposed blade linkage and arranged for normally-open or normally-closed operation as shown on the drawings. Multi-section dampers shall be provided with sufficient interconnecting hardware and jackshafts to provide unison operation of all blades in the entire assembly.

c. Ultra Low Leakage Control Dampers:

(1) Frames shall be 5" x 1" x 0.125" 6063 T5 extruded aluminum channel. Dampers 12" high and less shall be equipped with low profile (5" x 1/2") frame dimensions.

(2) Blades shall be 6" wide 6063 T5 heavy gage extruded aluminum airfoil shape.

(3) Axles shall be 1/2" plated steel hex for positive connection with blades.

(4) Bearings shall be non-corrosive two-piece molded synthetic.

(5) Blade seals shall be extruded vinyl double edge design with inflatable pocket which enables air pressure from either direction to assist in blade to blade seal off. Blade seals shall be locked in extruded blade slots without the use of cement.

(6) Jamb seals shall be aluminum flexible metal compression type.

(7) Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

(8) Dampers shall be rated for temperatures from -50^{o}F to 250^{o}F.

(9) Leakage rate shall be tested and rated in accordance with the Air Movement and Controls Association (AMCA) Standard 500.

(10) Dampers shall be Model CD50 ultra low leakage airfoil control dampers as manufactured by Ruskin or approved equal.

d. Damper Actuators:

(1) Damper actuators shall be direct mounted, electric, solid-state drive by Belimo or equal. Torque ratings sized to meet system requirements as determined by the Controls Contractor.

(2) Control inputs shall be On-Off/Floating control or proportional control as required.

(3) VAV controllers shall have auto zero function.

(4) The actuator assembly shall include all necessary hardware and brackets to allow proper mounting and connection to damper shafts.

10. Combination Fire/Smoke Damper - Airfoil Blade:

a. Frames shall be a minimum of 16 gage galvanized steel formed into a structural hot channel shape with tabbed corners for reinforcement.

b. Blades shall be airfoil shaped double skin construction with 14 gage equivalent thickness.

c. Axles shall be 1/2" plated steel hex.

d. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame.

e. Blade edge seals shall be silicone rubber designed to withstand 450^{o}F and jamb seals shall be stainless steel flexible metal compression type.

f. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

g. Each combination fire/smoke damper shall be 1-1/2 hour fire rated under U.L. Standard 555, and shall further be classified by U.L. as a leakage rated damper for use in smoke control systems under the latest version of U.L. Standard 555S, and bear a U.L. label attesting to same. Damper manufacturer shall have tested, and qualified with U.L., a complete range of damper sizes covering all dampers required by this Specification. Testing and qualifying a single damper size is not acceptable. The leakage rating under U.L. 555S shall be no higher than leakage class 1 (4 cfm/ft^2 at 1" w.g. and 8 cfm/ft^2 at 4" w.g.).

h. Dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions, with pressures of at least 4" w.g. in the closed position, and 4000 fpm air velocity in the open position.

i. The combination fire/smoke dampers and their actuators shall be

qualified under U.L. 555S to an elevated temperature of 350°F. Appropriate pneumatic actuators shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity which meets all applicable U.L. 555 and U.L. 555S qualifications for both dampers and actuators.

j. Dampers shall be Model FSD60 low leakage combination fire/smoke dampers as manufactured by Ruskin or approved equal. Dampers shall be provided with adjustable balancing settings where required or noted on the drawings.

11. Air Flow Measuring Stations:

a. Air flow stations for ducts and fan inlets shall be self-averaging traverse array measuring devices.

b. Device specifications shall comply with the following:

Accuracy	+/- 2% to 3%
Calibrated Range	0-5000 fpm

c. The maximum allowable pressure drop shall not exceed 0.015" wg at 1000 fpm.

d. Device shall be Advantage Gold Series by Ebtron with Model GP1 sensor for duct mounted locations and GF1 for fan inlet mounted sensors, gold anodized 6061 aluminum alloy tube, and 316 SST mounting brackets. Transmitter shall be electronic type with LCD display, 24 VAC power required, and 4 to 20 MA output.

E. Wiring:

1. Power Wiring: All 120 VAC power wiring shall be minimum #12 AWG as specified in Division 26 - Electrical.

2. Control Wiring:

a. All sensor and control signal wiring shall be a minimum #18 AWG or twisted shielded pair (TSP) as required.

b. Thermostat phone jack connectors shall be eight- conductor, #24 AWG, plenum-rated telephone cable with 8-pin RJ-45 connectors.

c. Communication wiring for network communication shall be Category 5 premises cable for high speed LAN applications. Cable shall conform to UL444, ICEA S-80-576, and TIA/EIA (TSB-36).

F. Conduit:

1. Unless noted otherwise, all power and all control wiring shall be routed in conduit. Plenum rated communication cable above ceilings may be

routed without conduit.

2. Conduit shall be in EMT (3/4" trade size minimum) conduit utilizing compression fittings. Set screw couplings shall not be used on control work.

3. Intermediate or rigid conduit shall be utilized for exterior application or as detailed. IMC and rigid conduit shall use screwed couplings with watertight joints.

G. Transformers:

1. Controls Contractor shall provide 120 VAC wiring from nearest power source for control power requirements.

2. Transformers shall be selected by the Controls Contractor for 24 VAC secondary voltage as required baud on primary voltages of 120 VAC, 208/240 VAC, 277 VAC, and 480 VAC.

3. Transformers shall be NEC Class 2, energy limiting or step-down type as required.

d. Secondary side shall have fuse protection.

H. Current Transmitters:

Output:	4-20 mA
Supply Voltage:	5-40 volts DC
Accuracy:	+/- 0.5% of full scale
Repeatability:	+/- 0.1% of full scale
Protection:	Reverse voltage protection; high over-current protection

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION: Prior to executing the work, carefully inspect the installed work of other trades and verify that all such work is complete and to the point where the control systems may be installed without damage. Coordinate with other trades.

3.02 INSTALLATION: All work shall be installed in strict accordance with the Drawings and Specifications by personnel directly in the employ of the Controls Contractor or his subcontractors.

A. It is noted that the Drawings and Specifications describe the approximate locations of the work. Do not scale the Drawings to determine exact positions and clearances. Obtain from the Owner's representative any dimensions not shown.

B. Bring to the attention of the Owner's representative immediately any changes in the size or location of the material or equipment which may be necessary in order to meet field conditions, or in order to avoid conflict with the equipment

of other sections of the Specifications. Obtain the Owner's representative's approval before such deviations are made.

C. Details of construction and of workmanship where not specifically described herein or indicated on the Drawings shall be subject to the Owner's representative's approval. It is the intent of these Specifications to provide complete systems, left in good working order, ready for operation, including necessary labor and materials, whether or not specifically shown on the Drawings or mentioned herein.

D. Obtain from the Owner's representative at the site the location of any apparatus not definitely located on the Drawings. Locate equipment and accessories in such a manner as to provide easy access for proper service and maintenance. Special care is required to provide accessibility to openings in equipment requiring maintenance. Bring to the attention of the Owner's representative any condition which prevents adequate accessibility for maintenance, prior to installation of that work.

E. Mounting of field microprocessors on air handling units shall not be allowed.

3.03 CONDUIT:

A. All control and power wiring shall be routed in conduit.

B. Conduit Supports:

1. Single runs shall use galvanized conduit straps or ring bolt type hangers with specialty spring clips. Plumber's perforated straps are not allowed.
2. Multiple runs shall use conduit racks with 25% spare capacity.
3. Vertical runs shall use channel support with conduit fittings.

C. Anchor Methods:

1. Hollow masonry shall have toggle bolts or spider type expansion anchors.
2. Solid masonry shall have lead expansion anchors or preset inserts.
3. Metal surfaces shall have machine screws, bolts, or welded studs.
4. Wood surfaces shall have wood screws.
5. Concrete surfaces shall have self-drilling anchors or power drive studs.

3.04 CONTROL PIPING AND TUBING: Control tubing shall be installed in a neat and workmanlike manner by trained mechanics in the direct employ of the control manufacturer per accepted industry standards.

A. All tubing and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces. Tubing may be run exposed in mechanical rooms or areas where other piping is exposed. Tubing shall be adequately supported to eliminate drooping or sagging.

B. Hard or soft drawn copper tubing, shall be used where buried in construction.

C. Tubing in equipment rooms, where exposed, shall be installed as hard copper tubing or polyethylene tubing in raceway conduit. Single terminal lines in equipment rooms shall be hard copper.

D. The piping system shall be leak tested by placing it under 25 psig pressure for a period of 2 hours. The pressure drop during the period shall not exceed 2 psig.

3.05 ELECTRICAL: The control system shall be installed according to the following provisions. All electrical work shall be installed in accordance with Division 26 - Electrical.

A. Power wiring for the control system shall be provided to the general location by the Electrical Contractor. Designated circuit breakers shall be furnished by the Electrical Contractor in the distribution panelboards for the control systems. Feeders shall be run to junction boxes by the Electrical Contractor as shown on the plans and control diagrams.

B. ELECTRICAL POWER shown on Electrical Drawings shall be provided to a local junction box by the Electrical Contractor. Wire, conduit, and connections to supply power to terminal units, panels, transformers, remote devices, and the like, shall be provided by the Controls Contractor.

C. All limited energy cable installed under this specification shall be UL listed and labeled for the specific use.

D. All wiring shall be in conduit. (All Junction Box covers shall be blue and have the word "CONTROLS" painted on them -- 3/8" high or larger.)

E. All electrical wiring shall comply with the National Electrical Code, Project Specifications, and shall be installed by licensed journeyman electricians.

F. Low voltage and line voltage wiring shall be installed in separate conduits.

G. All interlock and control wiring for the HVAC systems not shown on the Electrical Drawings shall be by the FMS Controls Contractor. This may include but not be limited to:

1. Sensor and transmitter wiring to DDC panels.

2. Safety interlocks to the starters, i.e. low and high pressure safety switches, smoke detector shut-down contacts, start/stop functions, and limit controls.

3. Wiring of thermostats or factory prewired panels furnished by others to control fans, and the like.

4. Trunk communication wiring.

5. Transformers, contactors, relays, and miscellaneous wiring and mounting.

3.06 WIRING SUPERVISION AND CHECKOUT: Supervision and checkout of the system shall be by factory trained engineers and technicians directly employed by the FMS Controls Contractor.

3.07 WORK BY OTHERS: The following work related to this Section shall be performed as

follows:

A. Automatic control valves, orifice plates, flanges, separable wells for immersion elements, and the like furnished by the FMS Controls Contractor shall be installed by the Mechanical Contractor under the FMS Controls Contractor's supervision.

B. Automatic dampers furnished by the Mechanical Contractor in ductwork and casings, and air flow measuring stations furnished by the FMS Controls Contractor, shall be installed by the Mechanical Contractor under the FMS Controls Contractor's supervision. It shall be the responsibility of the Mechanical Contractor to see that the dampers are correctly installed so that they operate freely and close tightly. It shall be the responsibility of the Mechanical Contractor to provide and install blank off plates when the control application requires dampers smaller than duct size.

C. Any finish painting required for control piping and control equipment shall be done by the FMS Controls Contractor.

D. Duct mounted smoke detectors shall be furnished by the Electrical Contractor, installed by the Mechanical Contractor, and wired by the Electrical Contractor.

E. Relays for interface with the Fire Alarm System shall be furnished, installed and wired to the Fire Alarm Control Panel by the Electrical Contractor.

3.08 INSTRUCTIONS AND ADJUSTMENT:

A. Upon completion of the project, the Controls Contractor shall have completely adjusted and calibrated the entire control system to operate as described in this section of the Specifications. The Contractor shall arrange to provide instruction to the Owner's personnel as part of the commissioning phase.

B. The Contractor shall submit to the Owner's representative six (6) sets of as-built drawings, and operating and maintenance manuals, to be approved and delivered to the Owner.

C. The Contractor shall obtain from the Owner a signed receipt that Owner's personnel have received complete instruction on the operation of the system.

D. Operator training shall include:

1. Sequence of operation review.
2. Sign on-Sign off.
3. Selection of all displays and reports.
4. Commanding of points, keyboard and mouse mode.
5. Modifying English text.
6. Use of all dialogue boxes and menus.
7. Modifying alarm limits and start-stop times.
8. System initialization.
9. Download and initialization of remote panels.
10. Purge and/or dump of historical data.
11. Use of portable operators terminals.
12. Troubleshooting of sensors (determining bad sensors).
13. Password modification.

14. Creation and modification of cardholder database.

E. Supervisor training shall include a two-hour session encompassing:

1. Password assignment/modification.
2. Operator assignment/modification.
3. Operator authority assignment/modification.
4. Point disable/enable.
5. Terminal and data segregation/modification.
6. Use of portable operator terminal.
7. Use of spreadsheet package with system data.
8. Creation and modification of site-specific user-defined cardholder fields.

F. Programmer training shall include at least eight hours of training encompassing:

1. Software review of Sequence of Operation and flowcharts.
2. Use of diagnostics.
3. System maintenance procedures.
4. Review of initialization.
5. Upload/download and off-line archiving of PCP and PC system software.
6. Graphic creation.

Programmer training shall be for two Owner personnel and shall be scheduled by the Owner with two-week notice anytime during the warranty period.

3.09 VALIDATION:

A. The FMS Controls Contractor shall completely check out, calibrate, and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operation submitted.

B. Witnessed validation demonstration shall consist of:

1. Running each specified report.
2. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
3. Step through penetration tree, display all graphics, demonstrate dynamic update and direct access to graphics.
4. Execute digital and analog commands in graphic mode.
5. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
6. Demonstrate FMS performance via trend logs and command trace.
7. Demonstrate scan, update, and alarm responsiveness.
8. Demonstrate spreadsheet/curve plot software and its integration with the database.
9. Demonstrate on-line user guide and help function.
10. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
11. Demonstrate multi-tasking.
12. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving and color banding.

3.10 MANUALS: The following manuals shall be provided:

A. An Operator's Manual with graphic explanations of operator functions. Although operator functions are to be self-instructional and menu-interactive from the keyboard terminal, this manual shall be for off-line study and refresher use.

B. Computerized printouts of all data file construction including all point processing assignments, physical terminal relationships, flowcharts of graphic program, etc.

C. A user manual for the integrated spreadsheet package.

D. Four (4) Operator's Manuals and four (4) As-Built Manuals shall be provided to the Owner.

3.11 SEQUENCES OF OPERATION:

A. General:

1. Hand-Off-Auto: The HOA switches shall be located locally at the units and shall be readily accessible. In the "Auto" position, the equipment shall be under the control of the FMS. In the "Hand" position the equipment shall operate independent of the FMS. In the "Off" position the equipment shall shutdown independently of the FMS or other remote control. Safety controls and FACP shutdown contacts shall shutdown fans with the HOA switch in any position.

2. Status: Proof of operation shall be by a current sensing relay installed on the power wiring or motor starter. An alarm shall be generated when the motor is enabled and the current sensing relay does not detect sufficient current to indicate a run status.

3. Thermometers: Temperature gages shall be permanently installed in the functional location shown on the control diagrams on the Drawings.

4. All system setpoints shall be adjustable as the Owner may find that setpoints may need to be adjusted to suit building operating conditions.

B. DEDICATED OUTDOOR AIR SYSTEM (DOAS)

The DOAS shall be indexed to run only during occupied hours for the building. During unoccupied hours, the DOAS shall remain off (supply fan and exhaust fan shall remain de-energized, exhaust and supply dampers shall remain closed).

In occupied mode, the controller shall index the DOAS to run via a field relay contact wired in series with the unit's low voltage control circuit. When the DOAS is indexed "on" for the occupied mode, the DOAS controls (furnished with the unit) shall index the supply and exhaust dampers "open" and index the supply and exhaust fans "on" via internal interlocks. Once indexed to run, the DOAS shall run subject to internal controls and safeties until the end of the occupied cycle.

Provide graphical display for the following points (minimum points as shown below):

1. Unit start/stop interface
2. Outdoor air temperature
3. Supply air temperature
4. Supply air humidity
5. Fan status
6. Filter status
7. Alarm status

C. VRF SYSTEMS

The VRF Systems Controller shall integrate with the FMS via BACNET module. The FMS shall provide for override of operation modes, setpoints and schedules.

Provide graphical display for the following points (minimum points as shown below):

1. Unit operation mode
2. Zone setpoint temperature
3. Zone temperature
4. Alarm status

END OF SECTION

SECTION 23 20 10
PIPE, PIPE FITTINGS, AND VALVES

PART 1 - GENERAL

1.01 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.02 RELATED WORK: Related work specified elsewhere:

A. Division 23 - Insulation

1.03 DEFINITIONS:

A. Design pressure of a zone of piping is the maximum pressure that can be predicted to occur in that zone, from an analysis of Drawings. Design pressure is not normally indicated on Drawings. Consult the Engineer if the design pressure for a particular zone is in question.

B. Flanging refers to the roll-back operation to form a flange using the pipe wall. It shall not be construed as the welding of a flange fitting to the end of a pipe, the coupling of pipes, or the coupling of pipes and fittings by means of flange fittings.

C. Furnace butt welded (or butt welded) pipe refers to a particular pipe manufacturing process. The term shall not be construed as the joining of steel pipe by means of a butt weld, or as the suitability of a particular type of pipe for butt welding.

D. Outside shall mean 5 feet beyond the perimeter of buildings.

E. Inside shall mean inside buildings and within 5 feet of the perimeter of buildings, except that footing drains are excluded.

F. Protected pipe refers to the coating or covering of an uninsulated pipe to make it suitable for exposure to outside weather, for direct burial in dry or wet earth, or for submarine installations in direct contact with water.

1.04 SUBMITTALS: Submit shop drawings in accordance with Section 23 0010 - Mechanical General Provisions:

A. Manufacturer's Certificate of Compliance.

B. Piping (Submit product data, construction and materials compliance data, dimensional data, and Country of origin for piping required by the Specifications for use on this project.)

C. Valves (Submit product data, construction and materials compliance data, dimensional data, and Country of origin for each valve or valve specialty type required by the Specifications for use on this project.)

PART 2 - PRODUCTS

2.01 PIPE, PIPE FITTINGS, VALVES AND ACCESSORIES shall be as listed in Section 23 2012. All pipe, pipe fittings, valves and installation accessories shall be manufactured in the USA. If USA manufactured valves are not available from the manufactures listed below, provide equivalent valves from one of the manufacturers listed.

2.02 PIPE FITTINGS: Welded, flanged, screwed, brazed, or soldered fittings for ferrous or copper piping shall be as manufactured by Crane, Nibco, Walworth, Stockham, Grinnell, Mueller, Weldbend, Tube Turns, or Chase and shall meet the requirements of the standards specified in the Piping Schedules. Threadolets and weldolets shall be Boney Forge, or equal.

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION:

A. Prior to all piping work, carefully inspect the work by other trades and verify that all such work is complete to the point where the piping may be installed in accordance with these documents.

B. Prior to all piping work, carefully inspect all existing conditions to verify that the piping may be installed in accordance with these documents.

C. Follow the Drawings in layout work and check drawings of other trades to verify sufficient space to install piping.

D. Undimensioned Drawings are intended to indicate the general arrangement of piping systems and are not intended to convey precise locational information.

E. Coordinate with other trades to permit the work of all trades to be installed.

F. Coordinate the work to insure that supports, sleeves and inserts are positioned accurately along with other built-in items, before concrete pouring takes place, so as to reduce to an absolute minimum the necessity for cutting or patching at a later stage.

G. Offsets, fittings, and extra pipe necessary to avoid interference, or provide maximum headroom and space shall be furnished and installed without additional expense to the Owner.

H. If the piping is installed without coordinating with other trades and interferes with work of other trades, the necessary changes shall be made at no extra charge.

I. The Drawings are generally diagrammatic and may not indicate all off-sets, fittings, and accessories which may be required. The Contractor shall investigate all potential obstructions carefully, plan ahead, and provide at no additional cost to the Owner such fittings, valves and accessories as may be required to meet such conditions.

3.02 INSTALLATION:

A. Excessive cutting and similar operations likely to weaken a structure or support to facilitate piping installation will not be permitted.

B. Prevent trash and dirt from entering pipes, before, during, and after installation, taking care and implementing suitable control measures throughout the construction period. Temporarily plug pipe ends as construction progresses, and until final connections are made.

C. Run piping parallel to walls of building, adjacent piping, fencing and the like, unless otherwise indicated.

D. Where pipe is to be insulated, provide a clearance equal to the insulation thickness plus a minimum of 2 inches.

E. Piping shall be worked in place without springing or forcing, and so as to properly clear all openings and equipment.

F. Piping shall be installed to permit free expansion and contraction without damage to joints or supports.

G. Thermal expansion of pipe shall be provided for in accordance with good trade practices. Use swing joints, turns, expansion loops, or long offsets, anchors and guides, as necessary to allow for and control pipe movement in accordance with ANSI B31.1.

H. Piping connections to equipment shall be installed in such manner that no excessive stresses will be transferred from the piping system to the equipment either during construction or operation.

I. Steel members shall be installed as required to support and anchor pipelines. Supports, anchors, or stays which may deform or alter the shape of the piping, during or after installation, shall not be used.

J. All changes in size and direction shall be made with proper pipe fittings; no miter fittings or joints will be accepted without prior approval of the Engineer.

K. Notching of copper tubing or plastic piping for connections will not be permitted.

L. All piping shall be cleaned and blown out just before installation.

M. Provide globe, ball, or butterfly type valves for throttling or drain service.

N. Valves shall be installed with stems vertical, horizontal or inclined upward. Valves shall not be arranged with stem below body.

O. Protect all water systems against freezing throughout the progress of the installation until final acceptance.

P. All water piping shall be protected in an approved manner from freezing at any future time under normal operating circumstances.

Q. All water piping shall be installed in such a manner that the entire system can be completely drained.

R. Protect pipes which are to receive a vapor barrier insulation from pipe hangers by using pipe saddles specifically designed for this purpose.

S. Provide dielectric isolation of connections between dissimilar metals.

T. Horizontal drain and waste piping within the building shall be given a grade of 1/4" per foot where possible but no less than 1/8" per foot. Piping 3" and smaller shall have minimum grade of 1/4" per foot. Main vertical soil and waste stacks shall be extended full size to the roof line and 12" above as vents, unless otherwise indicated on the Drawings. Fittings shall be service weight when used on service weight pipe. Fittings in extra heavy pipe shall be extra heavy weight. Reduction of the size of drainage piping in the direction of flow is prohibited. The use of double hubs, sleeves, inverted caulk joints, sanitary crosses, drilling and tapping of house drains, soils, waste or vent pipes and the use of saddles are prohibited.

U. Piping, including sanitary waste and vent piping, shall be installed straight and true to vertical and horizontal lines, with uniform slope for waste, vent, and drain lines. Deflection shall not exceed one degree. When necessary to achieve this alignment, provide additional hangers or bracing.

V. Slip joints of plumbing trap seals shall be used on inlet side only.

W. All flush valves shall be adjusted to give adequate but not excessive flushing action and shall be adjusted to operate as quietly as practical without sacrificing complete flushing action.

3.03 LAYOUT, CUTTING, AND FITTING UP:

A. Pipe and tubing shall be cut accurately to suit field conditions.

B. Pipe ends that are to be butt welded shall be beveled in accordance with ANSI B16.25.

C. Burrs shall be removed by reaming and other objectionable defects shall be removed by machining, chipping, or grinding.

D. Laterals ("Y" fittings) shall be used for branch connections in drainage piping, unless otherwise indicated.

3.04 CONCEALED PIPE:

A. In general, all pipe in finished spaces shall be run concealed in floors, walls, partitions and above ceilings.

B. Concealment and covering of pipe shall not be done until authorized by the Engineer, after proper tests have been made. This applies to all interior work and exterior work.

3.05 OPENINGS, SLEEVES & FLASHINGS:

A. Pipe sleeves shall be provided where pipes pass through walls, floors or partitions. Sleeves through floors shall be Schedule 40 steel pipe set flush with

bottom of slab and shall extend approximately 2" above the finished floor. Sleeves through partitions shall be Schedule 40 steel pipe flush with both sides of walls or partitions, and coated with rust inhibitive paint. Sleeves passing through concrete or masonry walls shall be Schedule 40 steel pipe set flush with the wall on both sides. Seal piping penetrations thru outside walls and floor for weatherproofing and leak tight.

B. Sleeves for insulated pipes shall be large enough to accommodate insulation and to permit expansion movement. Sleeves shall be larger in dimension that the outside diameter of insulation. Insulation shall be continuous through sleeves.

C. Support pipe from building structure where pipe penetrates walls to prevent resting on building wall or skin.

D. Where pipes penetrate firewalls, fire partitions, or fire rated floors, provide U.L. approved firestop seal between pipe and pipe sleeve in accordance with Section 23 0529, Supports, Anchors & Seals. Pack all other spaces between sleeves and insulation or pipe with fiberglass to make airtight unless indicated otherwise by U.L. approved installation methods.

E. When available to meet the same objectives described above, prefabricated, preinsulated "Pipe Shields" will be acceptable for pipes passing through floors, exterior walls, fire walls and fire resistive walls and partitions.

3.06 WELDED JOINTS:

A. Welded joints between sections of pipe and between pipe and fittings shall be in strict compliance with ANSI B31.1, Chapter 5, Section 127.

B. Each welded joint shall be stamped with the individual welder's identification number. See Quality Assurance in Part 1 of this section.

C. Make joints in piping for all services tight and leakproof against the design pressure.

D. Peening of welded joints to correct leaks will not be permitted.

E. Carbon steel pipe welding shall be done by the manual metal arc process using coated electrodes or gas arc (GMAW) process. All socket welds shall be made by manual metal arc processes.

F. Heat Treatment of Welds: No preheating of carbon steel piping is required, except no welding shall be performed on metal colder than 32^{o}F.

G. Welding shall penetrate the full wall thickness of the pipe. Slag shall be cleaned from each weld layer and any serious defects removed before the next layer is applied. The completed weld shall be cleaned of slag.

H. Preparatory to final welding, the proper gap shall be maintained while tack welding the pipe and connections in position so that a proper gap is made for a full penetration weld.

I. Tack welds shall be of the same quality and made by the same process as the rest of the weld, or they shall be removed prior to completion of the weld.

J. Small, sound, tack welds which penetrate to the bottom of the welding grove may become a part of the finished weld. Tack welds lacking penetration are not acceptable and must be removed. Large tack welds which almost fill the welding groove are not acceptable and must be removed.

K. Branch connection joints shall be prepared so as to permit full penetration welds of a quality comparable to the circumferential welds in the same piping system.

L. Permanently welded-in back-up strips shall not be used.

3.07 SOLDERED JOINTS:

A. Soldered joints between sections of pipe and pipe fittings shall be made using factory solder fittings with proper clearances between surfaces.

B. Immediately before soldering, thoroughly clean and burnish the joints with a crocus cloth or fitting brush especially made for this purpose.

C. Apply a suitable flux over the cleaned surface and apply heat with an air-acetylene or oxy-acetylene torch.

D. Use tin/silver solder as specified for material system. Solder containing lead, acid core solder or acid flux shall not be used.

E. Remove residue from flux.

F. Joints that leak shall be disassembled, cleaned and made again.

3.08 THREADED JOINTS:

A. Piping specified to be joined by threading shall be cut square to accurate lengths, and after threading shall be reamed to remove burrs and to provide full flow diameter of pipe through the joint.

B. Threads shall be cut full, clean, and concentric with the outside of the pipe. Threads shall be in accordance with ANSI B2.1 for taper threads.

C. Remove excess thread cutting lubricant from the inside and outside of pipe.

D. Threaded joints shall be made leak-tight by use of a suitable joint compound or teflon tape for pipe threads. (No. 51 Permatex pipe joint compound or equal), except as otherwise required by attached Piping Schedules.

E. When assembled, not more than three threads shall be visible at any joint.

F. Make joints in piping systems tight and leakproof against design pressures.

G. Care shall be taken to avoid over-tightening of threaded joints and to avoid damaging the pipe exterior with the pipe wrench.

H. Backing off of made-up threaded joints to facilitate fit-up or alignment will not be permitted.

I. Repair leaks in screwed or flanged joints which cannot be eliminated by normal wrench tightening methods by remaking the joint. Caulking will not be allowed.

3.09 FITTINGS:

A. Reducers: Make changes in pipe size by using factory made reducers. Use eccentric reducers in horizontal gravity flow systems with the flat side on bottom. Bushings, victaulic reducing couplings and field made reducers will not be permitted.

B. Tees, weldolets, sockolets and threadolets, or factory made tee fittings, shall be used for branch connections when the diameter of the branch connection does not exceed 50% of the diameter of the main; otherwise, factory made tee fittings shall be used for tee connections.

C. Elbows shall be factory made long radius type.

D. Unions: Install unions on each side of all threaded special valves, threaded regulators and similar items, on one side of each threaded check valve and at all pieces of unflanged equipment, so that such equipment might be readily disconnected and removed. Unions shall not be placed in a location which will be inaccessible after completion of the work.

E. Gaskets: Assemble flanges with gaskets specified in Piping Schedules at the end of this section.

3.10 LEAK TESTING OF PIPING SYSTEMS: Perform leak tests according to the applicable paragraphs in Section 23 05 93 - Tests.

3.11 CLEANING OF PIPING SYSTEMS:

A. The interior surfaces of piping shall be smooth and entirely free from obstructions to flow. Clean the systems before connecting to equipment or other systems.

B. Thoroughly clean all hot and chilled water piping systems using an alkaline cleaner, mixed in accordance with the manufacturer's recommendations. Where possible, heat the cleaning solution to approximately 160^{o}F and circulate for at least 24 hours in the system. When heat cannot be applied, circulate the cleaning solution for at least 48 hours. Afterwards, drain and flush entire system before refilling for final system start-up and operation.

3.12 PIPING SYSTEMS FILL AND START-UP:

A. After cleaning heating water and chilled water piping systems, refill each system with city water and install corrosion inhibitor and biocide water treatment chemicals as recommended by the chemical treatment supplier.

B. The Contractor shall notify the Engineer at least 48 hours prior to filling or adding chemicals to chilled water and heating water systems.

END OF SECTION

SECTION 23 2012
PIPING SCHEDULE - SERVICE & MATERIAL SYSTEM

I.D.	DESCRIPTION	OPERATING PSIG	OPERATING °F	MATERIAL SYSTEM	INSULATION SYSTEM	NOTES
CD	Condensate Drain, Cooling	ATM.	45	CP/3,PV1	C	1,3,4,5
RS	Refrigerant	Per Equipment Manufacturer Requirements				
RL	Refrigerant	Per Equipment Manufacturer Requirements				

REFERENCED NOTES:

1. Use rigid tubing and fittings for all copper piping.

2. Not used.

3. A continuous vapor barrier and a continuous insulation thickness, including all joints, fittings, valves, equipment and accessories, is required and is extremely important to prevent condensation.

4. Insulation thickness on condensate drain lines indoors serving air conditioning equipment shall be ¾ inch thick regardless of pipe diameter.

5. Exposed condensate drains on roof shall be schedule 80 PVC routed to roof drains. No insulation is required on drains outdoors.

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PIPE INSULATION SCHEDULE (See Section 23 0700 - Insulation)

System	Description	Pipe Size	Insulation
A (170-220°F)	Molded glass fiber with all service jacket (ASJ). Continuous vapor retarder not required.	1-1/2" & Smaller 2" & Larger	1.5" Thick 2.0" Thick
B (35-70°F)	Molded glass fiber with vapor retarder all-service jacket. Continuous vapor retarder, including sealing of joints, seams, staples, and the like is required.	1-1/2" & Smaller 2" & Larger	1.0" Thick 1.5" Thick
C (35-70°F)	Molded or sheet foamed plastic. Continuous vapor retarder, including sealing of joints, seams and the like is required. Provide finish jacket as scheduled.	1" & Smaller 1-1/4" & Larger	.75" Thick 1.0" Thick
D (35-70°F)	Molded phenolic. Continuous vapor retarder, including sealing of joints seams and the like is required. Provide finish jacket and/or finish as scheduled. Can be used up to 3” thickness in air plenums where 25/50 flame and smoke rating is required.	All Sizes	1.5" Thick

PIPING SCHEDULE - MATERIAL SYSTEM CP/3

Pressure Design: Atmospheric (For gravity drain systems) Temperature Design 100°F.

ITEM	SIZES	MATERIALS
Pipe	1-1/4" to 4"	ASTM B-88, Type L, Seamless, Hard Drawn Copper Tubing (above grade), Copper UNS Number C10800 (maximum 0.012 percent phosphorous). ASTM B-88, Type K, Seamless, Hard Drawn or Soft Annealed Copper Tubing (below grade), Copper UNS Number C10800 (maximum 0.012 percent phosphorus).
Fittings	1-1/4" to 4"	ANSI B16.29, Wrought Copper and Wrot copper Alloy Solder Joint Drainage Fittings - DWV or ANSI B16.23, Cast Copper Alloy Solder Joint Drainage Fittings - DWV
Flanges	ALL	ASTM B-62 and ANSI B16.18, Cast Brass, 125 lb., Flat Face, Socket Type Solder Joint.
Unions Threaded	1-1/4" & Larger	ASTM B-62 and ANSI B16.18, Cast Brass, Ends.
	1" & Smaller	ASTM B-62 and ANSI B16.18, Cast Brass, Solder joint.
Joints	Flanged	Garlock Full-Face Gasket
	Threaded	Commercial Grade Pipe Dope or Teflon Thread Tape.
	Solder	96/4 Tin-Silver (430° melting point, low temp.) for all services.
Studs & Nuts	ALL	ASTM A-307, Grade B, Zinc Plated Hex Head Machine Type.

PIPING SCHEDULE - MATERIAL SYSTEM PV/1

Pressure Design 160 psig at 73°F. Temperature Design 120°F

ITEM	SIZES	MATERIALS
Pipe	8" & Larger	Polyvinylchloride (PVC) pressure rated SDR 26 thickness Standard Dimension Ratio per ASTM D2241, for underground installation. PVC shall be Type I, Grade 1 per ASTM D1784.
Joints	PVC/PVC	Bell and spigot pipe ends with rubber 'O' ring gasket seals per ASTM D1869.
Joints	PVC/Steel	Ductile iron mechanical joint flange on PVC pipe with rubber gasket seal, AWWA C110 and AWWA C111, to mate with standard pipe flange.
Fittings	≤8"	Ductile iron mechanical joint each end with rubber gasket seals, Larger AWWA C110 and AWWA C111.
Anchors	>8"	Anchor connecting steel piping within 5 feet of connection point to eliminate any thrust, stress or torque from the steel pipe being transferred to the PVC pipe.
Thrust Blocks	ALL	Provide concrete thrust blocks at all changes of direction to prevent joints and fittings from being forced apart. Properly size thrust blocks to suit the forces involved and the bearing capacity of the soil.
Backfill	ALL	Tamp in place in six inch lifts. See details on drawings for dimensions and bedding materials. No rock shall be in the first foot of backfill above the pipe. Two feet of backfill, between top of pipe and grade, shall meet H-20 Highway Loading.
Testing	ALL	Hydrostatically test before backfilling at 120 psig for 4 hours, with no pressure loss except that due to ambient temperature change.

END OF SECTION 23 20 12

SECTION 23 31 13
METAL DUCTS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 REFERENCES: (Latest edition for listed references shall apply.)

A. ASHRAE Handbook - Fundamentals (latest edition): Duct Design chapter.
B. ASHRAE Handbook - Equipment (latest edition): Duct Construction chapter.
C. ASTM A90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.
D. ASTM A167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
E. ASTM A480 - Standard Specification for Stainless Steel Sheet, Plate and Strip.
F. ASTM A525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
G. ASTM A527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
H. ASTM B209 - Aluminum Alloy Sheet and Plate.
I. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
J. NFPA 90B - Installation of Warm Air Heating and Air Conditioning Systems.
K. SMACNA - Duct Construction Standards.
L. SMACNA - Fire, Smoke and Radiation Damper Guide for HVAC Systems.
M. UL 181 - Factory-Made Air Ducts and Connectors.

1.3 STANDARDS: Duct systems shall be in accordance with SMACNA Duct Construction Standards, the National Fire Protection Association, the North Carolina State Building Code, and manufacturer's recommendations where applicable.

1.4 SHOP DRAWINGS: Submit shop drawings of the following:

A. Ductwork layout and dimensions at minimum scale of 1/4" = 1'-0". (Refer to Section 23 00 10 - Mechanical General Provisions).

B. Construction details for special fabrications.

C. Ductwork accessories.

1.5 DUCTWORK MATERIALS:

A. HVAC Ductwork (General):

1. All HVAC ductwork, hangers, supports, and insulation shall be as scheduled in Section 23 31 15 and as indicated on the Drawings.

2. All galvanized steel HVAC ductwork, hangers, and supports exposed outdoors or exposed indoors in areas scheduled to receive finish painting shall be constructed of galvanized steel with "paint-grip" or similar mill surface etch treatment to create a paintable galvanized surface. Refer to Section 23 31 15 - Ductwork Schedule for materials

required at each location.

3. All low pressure insulated flexible ductwork shall meet the requirements of UL-181 Class 1 Air Duct, NFPA 90A and 90B, and the requirements of this Specification Section.

1.6 PRESSURE-VELOCITY CLASSIFICATION OF DUCTWORK: Classifications shall be according to Table 1-1 in the SMACNA HVAC Duct Construction Standards - Metal and Flexible - latest edition, the notes on the Drawings, and the schedules in Section 23 31 15 - Ductwork Schedule - Service and Material System.

1.7 DUCTWORK SEALING REQUIREMENTS

A. Sealing requirements shall be according to Table 1-2 in the SMACNA HVAC Duct Construction Standards and the information on the Drawings. Refer to Section 23 31 15 - Ductwork Schedule Service and Material Systems. Oil based caulking and glazing compounds shall not be used. Refer to Part 2 - Products of this Section for duct sealant specifications.

B. HVAC and Exhaust Air Ductwork:

1. Refer to Drawings and Section 23 31 15 - Ductwork Schedule for information on duct Seal Class requirements for specific duct systems.

2. Where not indicated on the Drawings or in schedules, the following duct sealing requirements shall apply:

a. One inch (1") water gauge pressure class ductwork shall meet Seal Class C.

b. Two inch (2") water gauge pressure class ductwork shall meet Seal Class B.

c. Three inch (3") and higher water gauge pressure class ductwork shall meet Seal Class A.

1.8 OFFSETS, BENDS, AND RELATED WORK: The Drawings covering the work of other trades, and all work already installed, shall be thoroughly examined and arrangements made to provide all necessary offsets, bends, or changes, including duct enlargements and streamlined pipe and hanger rod casings, as required to resolve and eliminate conflict with other trades.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.

B. Galvanized steel shall meet requirements of ASTM A90, ASTM A525 and ASTM A527, "Steel Sheet, Zinc Coated by the Hot-Dip Process, Lock-Forming Quality", based on G-90 coating.

C. Aluminum shall meet requirements of ASTM B209, "Aluminum Alloy Sheet and Plate," and shall be suitable for welding of duct joints.

D. Stainless steel shall be 300 series and shall meet requirements of ASTM A167 "Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip". Finish shall be as specified or scheduled, according to requirements of ASTM A480.

E. Insulated, low pressure flexible ductwork shall conform to the requirements of UL 181 and the requirements of this Specification Section.

F. Fasteners, such as rivets, bolts, or sheet metal screws, shall be of same material as duct system. Fasteners for galvanized steel shall be cadmium plated or galvanized steel, as appropriate for the Exposure Classification.

2.2 SUPPORTS AND HANGERS

A. Materials and Finish for supports, hangers, fasteners, and accessories shall be as scheduled for "hangers" in Section 23 31 15, and shall comply with the following:

1. System "BS" (black steel) shall be ASTM A-36 carbon steel with black or plain mill finish. Components shall be cleaned and painted with primer after fabrication. Primer shall be touched up after installation. Primer color shall be selected by Owner's representative.

2. System "GN" (galvaneal steel) shall be constructed of galvanized steel with "paint-grip" or similar mill surface etch treatment to create a paintable galvanized surface.

3. System "GS" (galvanized steel) sheet materials shall meet requirements of ASTM A90, ASTM A525, and ASTM A527, "Steel Sheet, Zinc Coated by the Hot-Dip Process, Lock-Forming Quality", based on G-90 coating. Hanger rods, rolled-shapes, and other parts shall be ASTM A-36 carbon steel with ASTM B633 SC1 or SC3 electro-plated zinc finish.

4. System "AL" (aluminum) sheet and formed shapes shall meet requirements of ASTM B209, "Aluminum Alloy Sheet and Plate," and shall be suitable for welding. Hanger rods, fasteners, and miscellaneous hardware shall be aluminum, stainless steel, carbon steel coated with Steelcote, or carbon steel coated with PVT Polymer. Galvanized or Cadmium plated steel shall <u>not</u> be used.

5. System "SC" (Steelcote) shall be ASTM A-36 carbon steel with plain finish. All components shall be properly prepared and coated with stainless steel filled urethane coating on all surfaces for corrosion resistant finish.

6. System "SS" (stainless steel) shall be 300 series and shall meet requirements of ASTM A167 "Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip". Finish shall be as specified or scheduled, according to requirements of ASTM A480. All components, including hanger rods, fasteners and hardware, shall be stainless steel.

B. Shop Coating Systems:

1. Shop Primer: Standard shop primer equal to Steel Structures Painting Council (SSPC) Specification No. 13. Total dry film thickness shall be not less than 2.5 mils. Verify compatibility of primer with specified finish paint. All miscellaneous steel supports provided for equipment, piping, and accessories furnished under Division 23 Specifications shall be fully coated with approved shop primer paint. Uncoated, bare steel supports will not be accepted.

2. Steelcote: MCU 2100 Type IV stainless steel filled urethane coating for superior abrasion, chemical, and corrosion resistance; 2 coats; 2 mils minimum dry film thickness per coat - 4 mils total. Product shall be manufactured by Steelcote Manufacturing Company.

3. Electro-Plated Galvanized: ASTM B633 SC1 or SC3 coating of zinc on steel by electrolysis from a bath of zinc salts. This coating is pure zinc and adheres to the steel with a molecular bond.

4. PVT Polymer: Highly corrosive resistant coating powder fused to metal; producing a hard, porcelain-like, abrasion resistant finish with good electrical, chemical, and outdoor weathering properties. Product shall be as manufactured by Michigan Hanger Company.

C. Fasteners such as rivets, bolts, or sheet metal screws, shall be of same material as support and hanger system. Fasteners for galvanized steel shall be cadmium plated or galvanized steel.

D. Hanger Rods shall be threaded continuously or threaded each end.

E. Hanger rods shall be subjected to tension only. Lateral and axial movements shall be accommodated by proper linkage in the rod assembly.

F. Support hangers by using malleable iron or carbon steel concrete attachment plates, beam clamps with lock nuts or retaining straps, or other special fastening devices, as required, for the support of hangers. Refer to specific details on the Drawings.

G. Beam Clamps:

1. C-clamps with locknuts shall be used where applicable for hanger rod sizes 3/8" - 3/4" diameter. C-clamps shall be fitted with integral retaining clamps. Clamp assemblies shall be plain carbon steel or electro-plated zinc finish.

2. Side beam brackets for attachment to structural members of wooden beams or trusses shall be malleable iron type with black finish, suitable for attachment using a lag screw; Grinnell Figure 202 or equal. Refer to details on the Drawings.

3. Welded beam attachments shall be used for rod sizes above 3/4" diameter and shall comply with hanger system materials as noted above.

H. Where ductwork cannot be suspended from overhead supports, use substantial welded wall brackets or trapeze supports, as conditions demand and as approved by the Owner's representative.

I. Construct fabricated supports and brackets of structural grade miscellaneous steel and fasteners. Black or plain steel components, which are not specified to have a special finish, shall be delivered to the job site with a prime coat of paint. Touch up primer after fabrication and after installation.

J. Provide all miscellaneous steel, bridging, brackets, anchors, frames, bracing, plates, bolts, nuts, washers, and the like, necessary to properly support ductwork. All steel, hangers and attachments shall be mounted to the building structure, concrete or masonry walls, structural concrete floors or concrete structural members. No attachments of any kind shall be made to the roof deck metal or floor deck metal. Refer to Section 23 00 10 - Mechanical General Provisions for paragraph entitled "Foundations, Supports, Piers, Attachments".

K. Provide bracing and supports for all vertical duct risers, with riser supports at each floor level.

L. Arrangement and fabrication of all supports shall be subject to Owner's representative's approval.

M. Perforated strap hangers and wire hangers will not be permitted, except for temporary supporting during construction. Solid strap hangers shall be permitted where trapeze hangers with angles and hanger rods cannot be installed due to space limitations and specifically approved by the Engineer in writing.

N. Hanging from unreinforced metal roof deck or from cellular roof deck will not be permitted.

O. Welded and bolted attachments to the building structural steel shall be in accordance with the requirements of AISC Specification for the Design, Fabrication, and Erection of Structural Steel Buildings.

P. All welds shall be performed by certified welders.

Q. Repaint all existing or new building steel where the paint is scraped or burned away during welding operations to match existing paint finishes.

R. Painting:

1. Immediately after surface preparations, apply shop paint in accordance with manufacturer's printed instructions, and at a rate to provide a uniform dry film thickness as specified.

2. Use painting methods that will result in full coverage of joints, corners, edges, finished welds, and all surfaces.

3. Painting materials and methods shall comply with Specification Section "Painting" in the Contract Documents."

2.3 FITTINGS, DAMPERS AND ACCESSORIES FOR ALL DUCT SYSTEMS shall be of the same material as the adjacent duct. Refer to Section 23 31 15 - Ductwork Schedule.

2.4 FITTINGS FOR FACTORY MANUFACTURED DUCT SYSTEMS shall be of same manufacturer as the duct system with all dimensions and components compatible.

2.5 ROUND ELBOWS AND FITTINGS shall be smooth, stamped type or five-piece type having centerline radius of 1-1/2 times the duct diameter as manufactured by Lindab or Eastern Sheet Metal.

2.6 RECTANGULAR ELBOWS & AIR TURNING VANES (based on SMACNA 1981 Systems Duct Design, Table 6-6):

A. All Ductwork:

1. Elbows in supply, return, exhaust, outside and relief air ductwork shall be SMACNA smooth radius type with two splitter vanes and with a 0.30 minimum inside R/W.

2. Mitered elbows without turning vanes shall NOT be used. Where mitered elbows are absolutely necessary because of space limitation, single thickness SMACNA Type 1 turning vanes with minimum 3/4" long trailing edges shall be provided. Turning vanes shall be same material as ductwork, and shall have same sealing requirement as ductwork.

3. Vanes over 30" long in mitered elbows shall be single thickness as above, with intermediate supports or tie rods, or shall be double thickness airfoil SMACNA Type 1 or 4.

4. Trailing edges of single thickness vanes shall be properly aligned parallel with the duct.

5. The number, size, spacing, and construction details of vanes shall comply with the SMACNA HVAC Duct Construction Standards.

6. Provide splitter vanes of similar construction in duct transitions and other locations, where shown on Drawings.

2.7 DUCT TAPE shall be 4” wide glass fabric tape imbedded in Foster 30-80 vapor barrier, fire resistant adhesive Do not use pressure sensitive tape.

2.8 DUCT SEALANTS shall be tested and labeled in accordance with UL-723 and conform to NFPA-90A Standards. Sealants shall be water soluble and shall exhibit good adhesive strength qualities and lifetime aging characteristics. Flame spread/smoke developed ratings shall not exceed 25/50 when cured. Duct sealant shall be Hardcast Irongrip Water-Based sealant, or approved equal. If a tape or scrim is used in conjunction with the sealant, it shall be compatible with the sealant and shall be recommended by the sealant manufacturer. For ductwork exposed to weather, sealant shall be suitable for outdoor use.

2.9 TRANSVERSE DUCT JOINTS: Transverse joints shall be selected and applied consistent with the static pressure class, applicable sealing requirements, ductwork materials of construction, duct support intervals, and duct reinforcement requirements

in accordance with SMACNA HVAC Duct Construction Standards. Notching, folding, bending and fit-up tolerances shall be appropriate for the composite duct assembly. Joints shall be sealed with approved materials in accordance with SMACNA Duct Sealing Requirements in Table 1-2 in the SMACNA HVAC Duct Construction Standards for the duct static pressure construction class. Bar or angle stock that is incorporated into the transverse joint shall be secured in accordance with SMACNA recommendations. Fasteners shall be appropriate for the ductwork materials of construction and shall be in accordance with SMACNA recommendations.

2.10 TRANSVERSE DUCT JOINTS (PROPRIETARY SYSTEM): (Contractor Option) For transverse joints, 36" wide and larger, transverse duct joints shall be accomplished using components manufactured and supplied by Ductmate Industries, or prior approved equal, and shall comply with the following requirements:

A. All angle steel components shall comply with ASTM A-527 with G90 galvanized finish. All corner steel components shall comply with ASTM A-526 with G90 galvanized finish.

B. Joint sealant materials shall be non-skinning, non-oxidizing product capable of withstanding joint movement without cracking so as to provide an airtight and watertight flexible joint seal. Product shall have maximum flame spread rating of 10, smoke developed rating of 25.

C. Gasket materials shall be Ductmate 440 Tape, or approved equal, and shall be as recommended by the joint system manufacturer. Gasket materials shall be non-skinning, non-oxidizing product capable of withstanding joint movement without cracking or excessive deformation so as to provide a functional airtight and watertight flexible joint seal. Product shall have a maximum flame spread rating of 10, smoke developed rating of 25.

D. Duct joint systems shall have been tested in accordance with SMACNA test procedures with test results certified in writing by an independent testing laboratory. Tests of joint performance shall clearly indicate whether or not an external sealant was applied in conjunction with the manufactured duct joint system.

1. SMACNA Class "J" transverse joints shall be accomplished using the Ductmate '35' Systems as manufactured by Ductmate Industries. The Ductmate '35' Systems shall not be used with duct gauges heavier than 16 gauge or lighter than 26 gauge, in accordance with the manufacturer's recommendations.

2. SMACNA Class "F" transverse joints shall be accomplished using the Ductmate '25' Systems as manufactured by Ductmate Industries. The Ductmate '25' Systems shall not be used with duct gauges heavier than 20 gauge or lighter than 26 gauge, in accordance with the manufacturer's recommendations.

E. All components used to form the transverse duct joint system shall be of standard identifiable catalog manufacture as supplied by Ductmate Industries, or approved equal. All hardware items shall be labeled by the manufacturer so that they may be easily identified as to source of manufacture.

F. The construction of the ductwork, with regards to sheet metal gauge,

reinforcing, seal class, and the like, shall be in strict compliance with the transverse duct system manufacturer's printed installation and applications literature, SMACNA duct construction standards, and the laboratory tested configurations of the duct joint system.

G. The transverse duct joint system shall conform to SMACNA guidelines and requirements for all transverse type joints. Finished joints shall maintain a deflection of less than 0.25" when the system is at standard operating pressure and shall maintain its structural integrity within the operating range of the system. The resulting mid-panel deflection of the joined ductwork sections shall not exceed 0.75" for ducts greater than 24" wide.

H. Transverse spiral and round duct joints may be accomplished with Spiralmate Round Duct Connector and accessory components as manufactured by Ductmate Industries or prior approved equal. Installation of Spiralmate Round Mate Connectors shall be in accordance with the manufacturer's printed instruction and installation manuals. The round connector shall consist of the following components: two mating round duct connector flanges with integral sealant; gasket between the two mating flanges; and a roll-formed closure ring that is drawn tight with a bolt and nut assembly.

I. The manufacturer of the components used to form the transverse duct joint shall guarantee all components against defective materials. The manufacturer shall also have factory trained representatives available to provide field assembly instructions to installing contractors.

J. Installation of all transverse duct joint systems shall be in strict compliance with the manufacturer's printed instructions.

K. All non-complying components and joint systems installed without approved Shop Drawing submittals shall be removed by the Contractor without additional expense to the Owner and shall be promptly replaced with approved components and joining methods for a complete system.

2.11 TDC AND TDF JOINT SYSTEMS: Duct joint connection methods classified as TDC or TDF (all are non-proprietary joints) shall be permitted provided the proposed duct construction meets duct pressure and leakage requirements specified herein. Contractor shall submit test results including air leakage date to the Engineer for review and pre-approval.

2.12 SPLITTER, BUTTERFLY AND MULTI-BLADE DAMPERS shall be in accordance with SMACNA duct construction standards for the specified pressure-velocity classifications.

2.13 MANUAL VOLUME DAMPERS

A. General: Refer to Section 23 31 15 - Ductwork Schedule for ductwork materials of construction for each HVAC system. For all systems, the materials of construction for the damper assembly shall match the materials of construction for the ductwork system in which it is to be installed. All damper assembly components and hardware, including frames, exposed to the airstream shall be alike in kind to the ductwork material and suitable for the intended application. For example, provide all stainless steel damper assemblies in stainless steel ductwork. Damper material gauges and construction features for aluminum or stainless steel dampers shall be

equivalent in strength and function to the Specifications in this Section concerning galvanized steel dampers.

B. Rectangular Dampers:

1. Manual rectangular dampers shall be constructed of minimum 16 gauge mill finish galvanized steel frames and blades with linkage out of the air stream. Dampers shall be opposed blade type and, unless noted otherwise, shall be furnished without blade edge seals. Blades shall be 6" wide, secured to nominal 1/2" diameter shafts. Bearings shall be molded synthetic type bearings or the equivalent. Furnish all manual dampers with a matching heavy duty hand quadrant with minimum 1-1/2" clearance for duct insulation systems. Manual dampers shall be Safe-Air Model 610, Ruskin Model CD35, or approved equal for duct velocities up to 1800 fpm. Where duct velocity exceeds 1800 fpm, provide manual dampers equal to Ruskin Model CD50 or CD60.

2. Manual dampers for duct sizes up to 180 square inches or smaller may be single blade type construction of 22 gauge galvanized steel frame and blade. Damper shall be Ruskin Model MD25 or approved equal. Furnish with integral locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems.

C. Round Dampers: Manual round dampers shall be constructed of minimum 20 gauge mill finish galvanized steel frames and blades with linkage out of the air stream. Dampers shall be single blade type and, unless noted otherwise, shall be furnished without blade edge seals. Control shaft shall be nominal 3/8" square axle shaft that extends beyond the frame to a factory mounted (or field supplied) heavy duty locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems. Manual dampers shall be Ruskin Model MDRS25, Safe-Air Model 613R, or approved equal.

D. Shop Fabricated Dampers (Rectangular or Round): In lieu of manufactured manual volume control dampers, the Contractor may construct shop fabricated damper assemblies in accordance with SMACNA HVAC Duct Construction Standards. Prior to fabrication, the Contractor shall submit shop drawings to the Engineer for approval. Shop Drawings shall indicate frame construction, blade construction, shaft type and size, shaft extension beyond duct wall, maximum and minimum sizes for each type of construction, material gauges, finishes, bearing assemblies, reinforcement, and the like. Furnish with integral locking hand quadrant with minimum 1-1/2" clearance for duct insulation systems.

2.14 CONTROL DAMPERS

A. Control dampers for HVAC systems shall be provided to allow effective modulation or close-off of air flow as required for each fan system. Damper frames shall be constructed to facilitate field assembly of several individual sections into larger damper area and shall be provided with openings or mounting clips to allow secure fastening of damper frame to the surrounding ductwork, collar, or fan housing. Maximum blade length in any section shall be 48". Additional stiffening or bracing shall be provided with suitable bearings for smooth operation and all blades shall be interconnected to provide unison operation.

B. Dampers shall be provided with either parallel or opposed blade linkage and arranged for normally-open or normally-closed operation as shown on the Drawings. Multi-section dampers shall be provided with sufficient interconnecting hardware and jackshafts to provide unison operation of all blades in the entire assembly.

C. Low Leakage Control Dampers:

1. Frames shall be 5" x 1" x 16 gage galvanized steel channel. Dampers 12" high and less shall be equipped with low profile (5" x 1/2") frame dimensions.

2. Blades shall be 6" wide galvanized steel airfoil shape.

3. Axles shall be 1/2" plated steel hex for positive connection with blades.

4. Bearings shall be non-corrosive two-piece molded synthetic.

5. Blade seals shall be extruded vinyl double edge design with inflatable pocket which enables air pressure from either direction to assist in blade to blade seal off. Blade seals shall be locked in blade slots without the use of cement.

6. Jamb seals shall be stainless steel flexible metal compression type.

7. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

8. Dampers shall be rated for temperatures from -50°F to 250°F.

9. Leakage rate shall be tested and rated in accordance with the Air Movement and Controls Association (AMCA) Standard 500 to have leakage ratings as listed below or better:

Damper Width	Maximum System Pressure	Maximum System Velocity	Leakage % of Max. Flow	Leakage CFM/ Sq. Ft.
48"	6.2 in. wg.	4000 fpm	0.067	2.7
36"	8.5 in. wg.	4000 fpm	0.075	3.0
24"	10.75 in. wg.	5000 fpm	0.060	3.0
12"	13.0 in. wg.	6000 fpm	0.050	3.0

10. Dampers shall be Model CD60 low leakage airfoil control dampers as manufactured by Ruskin, Arrow, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Johnson Controls, and Safe-Air.

2.15 INSTRUMENT PORTS shall be Duro Dyne Air Tight Instrument Test Port with neoprene expansion plug for instruments up to 1-1/32 and flat neoprene mounting gasket, or equal. Ports shall be air tight with heavy duty die cast construction, zinc plated heavy gauge cap and instant release wing nut.

2.16 ACCESS DOOR LATCH shall be Ventfabrics, Inc. No. 260 "Ventlock", or equal latch for

doors large enough to enter only.

2.17 QUADRANTS, CONTROLS, INDICATING INSTRUMENTS and similar equipment shall be provided with extensions and/or brackets for mounting on the surface of the insulation of externally insulated ducts.

2.18 SUPPORT AND BRACING MATERIAL for galvanized ductwork shall be galvanized steel. Dielectrically isolate galvanized steel supports from aluminum duct with two coats of zinc-chromate paint or bitumastic paint. Support and bracing material for stainless steel ductwork shall be stainless steel.

2.19 FLEXIBLE CONNECTIONS

A. Large Flexible Connections (Greater than 8 feet total duct perimeter):

1. Connections shall be made with Duro Dyne Type "Super Metal Fab" wide span fabric or equal.

2. Fabric shall be 6" wide Excelon type by Duro Dyne. Fabric shall be of tear resistant construction with a no-tear nylon base cloth. Fabric shall be suitable for outdoor use where required. Weight of fabric shall be approximately 22 oz. per sq. yd.

3. Integral metal connector pieces shall be nominal 3" wide, 24 gauge, metal "Grip-Loc" seam or equal.

4. Fabric and fabric assembly shall be UL listed and NFPA 90A approved.

B. Flexible Connections (Smaller than 8 feet total duct perimeter):

1. Connections shall be made with Duro Dyne Type "Metal Fab" fabric or equal.

2. Fabric shall be 3" wide Neoprene type by Duro Dyne. Fabric shall be of durable construction consisting of a heavy glass fabric double coated with Neoprene. Weight of fabric shall be approximately 30 oz. per sq. yd.

3. Integral metal connector pieces shall be nominal 3" wide, 24 gauge, metal "Grip-Loc" seam or equal.

4. Fabric and fabric assembly shall be UL listed and NFPA 90A approved.

2.20 DUCT SLEEVES through floors shall be at least 14 gage galvanized steel.

2.21 RECTANGULAR FIRE DAMPERS shall be as follows:

A. Duct mounted dampers shall be factory built curtain type, with blades out of airstream (Type B). Dampers installed at sidewall registers or grilles shall be factory built curtain type, with blades in the airstream (Type A).

B. Dampers located in aluminum or stainless steel ductwork shall be constructed entirely of 304 stainless steel.

C. Dampers shall have a minimum 1-1/2 hour fire protection rating and shall include a U.L. label in accordance with UL555 standard.

D. Dampers shall have a dynamic label that shall illustrate maximum allowed CFM at 8" static pressure for in-duct mounting and maximum allowed CFM at 4" static pressure for non-ducted, in-wall mounting.

E. Dampers shall have vertical and horizontal closure spring operation for assured closure under airflow.

F. Provide factory built sleeves of design and length to permit mounting within the opening, and as required to meet local code requirements.

G. Factory manufactured fire dampers shall be by Ruskin, Prefco Products, Louvers and Dampers, Inc., or approved equal.

H. Fusible links shall be temperature rated in accordance with NFPA 90A.

I. Each fire damper type and rating shall be as required to maintain the fire resistive construction rating of the floor, wall or partition in which it is installed.

J. See Drawings for additional information and requirements.

2.22 ROUND FIRE DAMPERS

A. Duct mounted fire dampers in round ducts shall be round type with butterfly damper and linkage with fusible link located within the air stream.

B. Dampers located in galvanized duct systems shall be galvanized steel construction. Dampers located in aluminum or stainless steel duct systems shall be constructed entirely of 304 stainless steel.

C. Dampers shall have a minimum 1-1/2 hour fire protection rating and shall include a UL label in accordance with UL 555 Standard.

D. Dampers shall have a dynamic label that shall illustrate maximum allowed CFM at 8” static pressure for in-duct mounting and maximum allowed CFM at 4” static pressure for non-ducted, in-wall mounting.

E. Provide factory built retaining plates of design and length to permit mounting within the opening and as required to meet local code requirements.

F. Factory manufactured fire dampers shall be Ruskin Model FDR25 or approved equal by Prefco Products, or Louvers and Dampers, Inc.

G. Fusible links shall be temperature rated in accordance with NFPA 90A.

H. Each fire damper type and rating shall be as required to maintain the fire resistive construction rating of the floor, wall or partition in which it is installed.

I. See Drawings for additional information and requirements.

2.23 COMBINATION FIRE AND SMOKE DAMPERS

A. Combination fire and smoke dampers and actuators shall be rated for 2000 fpm at 4" w.g. and elevated temperature of 250°F. Dampers shall have a UL555 fire rating of 1 ½ hours and shall meet the requirements of UL555S Leakage Class 2.

B. Frames shall be 5" x 16 gage galvanized steel channel.

C. Blades shall be one piece airfoil, 6" wide, 16 gauge minimum galvanized steel.

D. Axles shall be 1/2" minimum plated steel with stainless steel bearings pressed into frame

E. Blade seals shall be silicone edge type mechanically fastened to blades and rated for up to 450 deg, F. Galvanized steel seals shall provide flame seal to 1900°F.

F. Jamb seals shall be stainless steel flexible metal compression type.

G. Linkage shall be concealed in frame for low maintenance and reduced air turbulence.

H. Dampers and controls shall be as scheduled on the drawings and shall be manufactured by Ruskin, Arrow, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Johnson Controls, and Safe-Air.

2.24 FIRESTOP SEALS: All holes, voids, or openings created to extend mechanical systems through fire rated floors, partitions and walls shall be sealed by the Contractor with an intumescent material capable of expanding up to 10 times when exposed to temperatures beginning at 250°F. It shall be UL Classified and have ICBO, BOCAI, and SBCCI (NER 243) approved ratings to 4 hours per ASTM E-814 (UL 1479). Manufacturers shall be 3M, or equal by Dow Corning.

2.25 RADIATION DAMPERS

A. Where not supplied as an integral diffuser, damper, and blanket assembly; ceiling fire damper assemblies shall be provided to maintain rated Floor/Ceiling assemblies.

B. Dampers shall be U.L. listed for rated assemblies and sized per opening.

C. Dampers and accessories shall be Ruskin, Prefco Products, or approved equal.

2.26 ACCESS DOORS

A. Access doors shall have minimum 22 gauge frames and 24 gauge door panels. Materials of construction for the access door and all hardware shall match the duct system materials of construction.

B. Doors shall have continuous hinge assemblies.

C. Latches shall be sash type with matching strikes.

D. Doors shall be double wall construction with 1" thick enclosed fiberglass insulation.

E. Gaskets shall be PVC foam type or neoprene, and comply with the requirements of NFPA 90A for flame spread and smoke developed ratings.

F. If space does not permit door opening, removable door models may be used.

G. Access doors for round ductwork shall be of the rolled hinge plate design shaped to match the contour of the duct or bolted access door design with integral hand operated knobs to create a compression fit with the duct wall. Bolted type round duct access doors shall be Sandwich type by Ductmate Industries, or equal, and shall comply with the requirements of the general paragraphs above relating to access door construction.

H. Rectangular access doors for rectangular ductwork shall be Cesco Model HAD or CAD, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Safe-Air, and Ruskin. Round access doors for rectangular ductwork shall be Flexmaster "Inspector Series" access doors, or approved equal by National Controlled Air, Louvers & Dampers, Inc., Safe-Air, and Ruskin.

2.27 MOISTURE DRAIN: Provide where shown on plans. Duct mounted moisture drains shall be Ductmate Industries Moisture Drain, or approved equal. The drain connection shall be accomplished by drawing a portion of the duct wall into a funnel shape. The base of the moisture drain shall be 12 gauge galvanized steel to resist deformation. The drain shall consist of a chrome-plated brass threaded drain, nut, and cap. The drain installation shall provide a leakproof connection. Minimum size of drain shall be 3/4".

2.28 PLENUM WALL CONSTRUCTION

A. Plenum wall panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets. Plated fasteners will not be accepted.

B. All panels shall be double wall smooth mill finish aluminum construction with minimum 0.040" aluminum exterior and interior skin thickness. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

C. The minimum panel thickness shall be 2" thick with polyisocyanurate foam insulation. Panel shall comply with NFPA 90A requirements.

D. Casing design static pressure shall be at 6" w.g. positive and 6" w.g. negative. Thickness of the panel skin, core density, rib structural frame spacing shall be regulated to eliminate panel pulsation and restrict the maximum deflection to 1/200 of any span at design load of 1-1/2 times the design positive or negative pressure. Casings shall be built to exceed AMCA Class "C" requirements.

E. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no more than 1% of the design volume at the design operating pressure or 30 CFM, whichever is greater.

F. Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.

G. Any equipment flashing shall be made in such a way to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.

H. All ductwork and air handling unit connections shall be made with flanged connections of same material as the wall panel. Pipe and conduit penetrations through panels shall be properly sealed with gaskets. Penetrations sealed by simply caulking around extension are not acceptable.

I. Access doors shall be of the same construction as panels described above. Provide automotive style neoprene gasketing around full perimeter of access doors to prevent air leakage. Provide "ventlock" style non-corrosive alloy latches operable from the inside or outside of unit. Provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

J. Each access door shall be provided with minimum 10” square, thermopane safety glass window.

K. Each access door shall be mounted with a corrosion-resistant stainless steel continuous piano hinge.

L. Removable access panels shall be provided as required for service and maintenance. Access panels shall be of the same construction as the panels. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels. Airtight integrity must be maintained.

2.29 INSULATED FLEXIBLE DUCTWORK

A. Low pressure flexible duct shall be a factory fabricated assembly of a trilaminate of reinforced aluminum foil vapor barrier, fiberglass insulation, and CPE inner film with high tear strength, and properties to resist temperature change, mildew, and age hardening.

B. The liner shall be mechanically locked, without adhesives, into a corrosive resistant galvanized steel helix formed on the ducts outside surface.

C. The duct shall be a U.L. listed 181 Class 1 duct material and shall comply with NFPA 90A and 90B.

D. The material shall have a positive pressure rating of not less than 6” w.c. through a temperature range of –20 to 250ºF.

E. The duct material shall be factory wrapped in a thick blanket of fiberglass

insulation with a C factor of 0.23 or less.

F. The insulation shall be encased in a fire retardent reinforced aluminum material vapor retarder with a perm rate of not over 0.05.

G. The duct shall be rated for 4000 fpm duct velocity.

H. Provide adjustable diameter type self-locking nylon clamps as manufactured by Panduit, or equal.

I. Flexible duct shall be Type 8M as manufactured by Flexmaster or equal by Thermaflex.

J. Take-offs for flexible ductwork shall be made using Flexmaster Model SRO (or approved equal) rectangular to round side take-offs with integral balancing damper. Damper shall be provided with locking quadrant handle, and insulation standoff.

2.30 SOUND ATTENUATORS

A. Sound attenuators shall be Ruskin Type AM or Engineer approved equal. Attenuators shall be factory assembled, broad band rectangular type, with 8 inches w.g. operating pressure, 18 gauge G90 galvanized steel outer casing, 22 gauge G90 perforated galvanized steel internal liner, and glass fiber fill acoustic material, with mylar liner.

B. Acoustical performance shall meet or exceed schedule values in accordance with ASTM E477 testing procedure.

C. Static pressure loss shall not exceed scheduled values.

2.31 DUCTWORK ACOUSTICAL LAGGING

A. Acoustic lagging shall be moisture resistant gypsum wall board completely covering top, bottom and sides of ductwork. Lagging shall be attached with galvanized sheet metal screws on 8″ centers each way. Edges and seams shall be overlapped a minimum of 4″. Joints at access doors, walls, and other locations shall be tightly butted and sealed with canvas and vapor retardant mastic.

B. Acoustical lagging thickness shall be two layers of ½″ thick moisture resistant gypsum wall board with staggered joints.

C. Hangers for ducts with acoustical lagging shall be sized for the intended load and spaced at not greater than 5 ft between each hanger.

2.32 VIBRATION ISOLATION HANGERS

A. Spring Hangers: Spring hanger shall be Mason industries type 30 with 1″ deflection and neoprene bridge bearing or equal by VMC or B Line.

B. Neoprene Vibration Isolation Hangers: Hangers shall be Mason Industries Type HD or equal by VMC or B Line.

PART 3 - EXECUTION

3.1 DUCTWORK

A. All ductwork, hangers, and supports shall be fabricated and installed in accordance with applicable SMACNA Standards according to the pressure class described in PART 1 - GENERAL.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

C. Ductwork shall be supported as recommended by SMACNA Standards from structural members. Ductwork shall not be allowed to rest on ceiling, light fixtures or structural members. Ductwork supported from joists shall be supported from the top chord of joists.

D. Ducts, unless otherwise approved, shall be true to dimensions indicated, straight and smooth on inside with neatly finished joints, securely anchored to building in an approved manner, and installed to be completely free from vibration or chatter under all conditions of operation. Exact routing of ductwork will be dependent on location of structural members, and coordination with locations of other utilities. Route duct to avoid cutting structural members.

E. Brace ducts not more than 60 inches on center. Make slip joints in direction of flow, unless shown otherwise on the Drawings. Off-set ducts around obstructions where possible. The total included angle of duct tapers or transitions shall not exceed 45^{o} for diverging air flow or 60^{o} for converging air flow. However, in no case shall the angle between the air flow path entering the transition, and any side of the transition, exceed 30^{o} for diverging or converging air flow. In general, diverging transitions shall be limited to 15^{o} from the air flow path, and the above angles shall be considered maximum requirements.

F. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent of duct area, split into two ducts, maintaining original duct area.

G. Use double nut and lock washers on threaded rod supports.

H. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

I. Provide dielectric isolation between aluminum ductwork and steel materials at ductwork joints and supports. Isolation may be provided with two coats of zinc-chromate paint or bitumastic paint. Ensure that there is no metal to metal contact.

J. All ductwork accessories shall be installed in strict accordance with manufacturer's recommendations.

3.2 SPECIAL ITEMS OF EQUIPMENT: Install special items of equipment in the duct

systems, including automatic dampers, thermostats, humidistats, thermometers and other related controls, under the direct supervision of the Controls Contractor. Install fire alarm system smoke and temperature sensors under the direct supervision of the Electrical Contractor.

3.3 QUADRANTS, CONTROLS, INDICATING INSTRUMENTS: Mount quadrants, controls, indicating instruments and similar equipment on the surface of the insulation of insulated ductwork.

3.4 ENLARGE DUCTS designated to be lined by an amount equal to the lining thickness, so as to maintain the indicated air flow dimensions. Duct lining shall be in accordance with Section 23 07 00 - Insulation.

3.5 CROSS BREAK OR BEAD DUCTWORK having a width or depth in excess of 12 inches.

3.6 VOLUME CONTROL: Provide volume control and balancing dampers of the splitter, butterfly or multi-louver type for controlling air volume and direction and for balancing the system. Stiffen ducts at damper locations to provide adequate rigidity. Provide balancing damper for each supply diffuser or grille where branch duct connects to supply duct.

3.7 ACCESS DOORS: Provide access doors in duct for all automatic dampers, fire dampers, controls, filters and similar equipment.

3.8 INSTRUMENT PORTS: Provide instrument ports in ductwork for pitot tube test where required for air flow measurement. Coordinate with TAB Contractor.

3.9 FLEXIBLE CONNECTIONS: Seal flexible connections and firmly band at each connection point. Flexible connections shall be not less than 4 inches in length.

3.10 DUCT SEALING: Sealing shall be done as required in Part 1 - General in this section, using duct sealer, duct sealer and tape, or gaskets in accordance with SMACNA duct construction standards, manufacturer's recommendations, and this Specification.

3.11 SLEEVES THROUGH FLOORS

A. Provide sleeves through floors for all ducts passing through floors, except where ducts are enclosed in a sealed chase. Sleeve shall extend 2 inches above finished floor and shall be secured permanently in place.

B. Construct watertight joint between sleeve and floor with sufficient reinforcing to assure permanent watertightness.

C. Provide cover at the bottom of the sleeve and pack space between sleeve and duct with fiberglass insulation.

D. Where fire dampers are required, omit the sleeves but make the joint between the fire damper collar and the floor watertight.

3.12 FIRE DAMPERS

A. Fire dampers shall be installed at all locations where ductwork penetrates any floor, wall or partition with a fire rating of 2 hours or more, and where

otherwise shown or specified on the Drawings.

B. Fire dampers shall be installed at all locations where ductwork penetrates walls or partitions with a 1 hour fire rating. Fire dampers may be omitted where fire dampers are not shown on plans provided the sheet metal duct is 100 square inches or less, does not communicate the corridor with adjacent spaces, is installed above a ceiling, and does not terminate at a wall register in the fire rated wall.

C. Install fire dampers in accordance with manufacturer's UL approved printed instructions, or SMACNA's Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, whichever is more stringent.

D. Provide and locate access door to allow easy adjusting and link replacement.

E. Adjust fire dampers as follows:

1. Disconnect fusible link.

2. Operate the fire damper several times.

3. Adjust and correct each fire damper to assure free, positive operation and proper latching.

4. Reconnect fusible link.

3.13 FIRESTOP SEALS shall be installed in strict accordance with the manufacturer's recommendations for each type of opening or void. Surfaces shall be smooth and without gouges or other irregularities.

3.14 DUCT SMOKE DETECTORS shall be furnished by the Electrical Contractor under Division 16 and installed in the duct system by the Mechanical Contractor. All wiring and interlocks shall be furnished and installed by the Electrical Contractor.

3.15 CLEANING

A. All ductwork shall be thoroughly cleaned inside and out prior to system startup, and shall be left in a neat and orderly manner. Duct sections, open ends, taps, and the like shall be covered with plastic at <u>all</u> times during construction to prevent entry of dust and debris.

B. See Section 23 00 10 - Mechanical General Provisions, and Section 23 05 93 - Tests, for additional requirements.

3.16 STARTUP, TESTING, ADJUSTING & BALANCING: See Sections 23 00 10 - Mechanical General Provisions, and 23 05 93 – Testing, Adjusting and Balancing for HVAC.

END OF SECTION

SECTION 23 31 15
DUCTWORK SCHEDULE - SERVICE & MATERIAL SYSTEM

A. GENERAL NOTES & LEGENDS:

1. Refer to Section 23 3113 - Ductwork, and Section 23 0700 - Insulation, for detailed material and installation requirements. Refer to Section 23 3113 for insulated flexible ductwork. Note: Not all materials described in Part A of this Specification are used on this project. Refer to attached schedules for required material applications.

2. Ductwork & Hanger Material Legend: (See Section 23 3113 - Ductwork)

System	Description
AL	Aluminum
BS	Black Steel
GN	Galvaneal Steel ("PAINTGRIP")
GS	Galvanized Steel
SC	Black Steel with Steelcote S.S. Filled Urethane Finish
SS	Stainless Steel (304)

3. Material Schedule - Ductwork Insulation: (See Section 23 0700 - Insulation)

System	Description
A	Molded glass fiber
B	Rigid glass fiber
C	Flexible glass fiber - 0.75 lb/cu. ft. ductwrap
D	Glass fiber duct liner - 1.5 lb/cu. ft.
E	Glass fiber duct liner - 3.0 lb/cu. ft.
F	Foamed plastic without finish
G	Foamed plastic with 2-coat finish
H	Phenolic foam
J	Engineered Polymer Foam Duct Liner (FPFI)

4. Jacket Material Legend: (See Section 23 0700 - Insulation)

System	Description
A	Foil-Scrim-Kraft
B	Canvas - field applied
C	Fiberglass - field applied
D	PVC sheet - field applied, solvent weld
E	Aluminum sheet - field applied
F	Stainless Steel - field applied

5. Insulation Thickness Legend:

050	=	1/2" Thick
075	=	3/4" Thick
100	=	1" Thick
150	=	1-1/2" Thick
200	=	2" Thick
250	=	2-1/2" Thick
300	=	3" Thick

B. SERVICE & MATERIAL SYSTEMS: See the following DUCTWORK SCHEDULE.

C. SCHEDULE NOTES:

1. See Drawings for detailed requirements.

2. Flexible ductwork shall not be used upstream of VAV terminal units.

3. See specific ductwork and insulation requirements at VAV terminal unit detail on Drawings.

4. Insulate exterior of heating coil and adjacent ductwork per equipment insulation schedule in Section 23 0700.

5. Firestop duct penetration thru wall. Do not extend insulation thru wall.

6. Provide dielectric isolation between aluminum ductwork and steel materials at ductwork joints and supports. Isolation may be provided with two coats of zinc-chromate paint or bitumastic paint. Ensure that there is no metal to metal contact.

7. Supply and return ducts located in unconditioned spaces shall be insulated with a minimum of R-5 insulation in accordance with 2012 NC Energy Code.

8. Supply and return ducts located outside of the building shall be insulated with a minimum of R-8 insulation in accordance with 2012 Energy Code.

SECTION 23 31 15 - DUCTWORK SCHEDULE - SERVICE & MATERIAL SYSTEMS

DUCTWORK SYSTEM: DUCTWORK LOCATION:		DOAS	VRF UNITS			
Supply Air	Temperature Range	50°F-100°F	50°F-100°F	-	-	-
	Ductwork Material	GS	GS	-	-	-
	Hanger Materials	GS	GS	-	-	-
	Insulation	100C	200C	-	-	-
	Jacket	A	A	-	-	-
	Pressure Class (in.)	2.0	1.0	-	-	-
	Seal Class	A	A	-	-	-
Return Air/ Exhaust	Temperature Range	50°F-100°F	55°F-85°F	-	-	-
	Ductwork Material	GS	GS	-	-	-
	Hanger Materials	GS	GS	-	-	-
	Insulation	-	200C	-	-	-
	Jacket	A	A	-	-	-
	Pressure Class (in.)	2.0	1.0	-	-	-
	Seal Class	A	A	-	-	-
Outside Air	Temperature Range	-	-	-	-	-
	Ductwork Material	-	-	-	-	-
	Hanger Materials	-	-	-	-	-
	Insulation	-	-	-	-	-
	Jacket	-	-	-	-	-
	Pressure Class (in.)	-	-	-	-	-
	Seal Class	-	-	-	-	-
Relief Air	Temperature Range	-	-	-	-	-
	Ductwork Material	-	-	-	-	-
	Hanger Materials	-	-	-	-	-
	Insulation	-	-	-	-	-
	Jacket	-	-	-	-	-
	Pressure Class (in.)	-	-	-	-	-
	Seal Class	-	-	-	-	-

*Low pressure supply ductwork, downstream of VAV boxes, may be constructed for 1” Pressure Class.

END OF SECTION 23 31 15

SECTION 23 37 13
DIFFUSERS, REGISTERS, AND GRILLS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 DEFINITIONS:

A. Diffusers are ceiling mounted air supply outlets with built-in volume and flow direction adjustments. Diffusers are intended to rapidly mix supply air with room air.

B. Linear diffusers have one or more long slot-type air supply outlets with built-in volume and flow direction adjustments. Linear diffusers may be ceiling, wall or floor mounted.

C. Supply grilles and registers are ceiling, wall or floor mounted air supply outlets with adjustable vertical and/or horizontal air direction vanes. Vertical vanes shall be on the room side of wall mounted units.

D. Return grilles and registers are ceiling, wall or floor mounted air return or transfer inlets with fixed vertical and/or horizontal vanes. Vertical vanes shall be on the room side of wall mounted units.

E. Registers have built-in volume adjusting opposed-blade dampers, whereas grilles do not.

F. High capacity industrial grilles are wall or ceiling mounted air supply outlets offering directional control of large air volumes.

1.3 CEILING DIFFUSERS, GRILLES AND REGISTERS shall be as scheduled on Drawings.

1.4 ADJUSTABLE AIR EXTRACTORS shall be provided behind supply grilles and at branch ducts where shown on the Drawings and scheduled on the air distribution schedules.

1.5 SOUND PRESSURE LEVEL of all diffusers, grilles and registers shall not exceed NC 30 (unless otherwise scheduled) in all areas, at the scheduled maximum air flow. NC ratings are based on sound power level re 10^{-12} watts minus an 8 db room attenuation in all octave bands.

1.6 SHIPPING TAG: Each unit shall be tagged at the factory with its specific location on the job, including building floor, room/area served, and the unit designation shown on the Drawings.

1.7 SUBMITTALS: Submit the following for each air distribution device:

A. Manufacturers details indicating components, dimensions, connections, clearances.

B. Performance criteria indicating type, size, total static pressure, cfm, NC rating, neck size, and throw pattern on each individual device.

C. Materials of construction.

D. Finishes.

E. Accessories and options.

F. Installation details and mounting methods.

G. Reference to the Contract Documents for performance information is unacceptable.

1.10 SAMPLES: Submit samples of diffusers, grills and registers at the request of the Engineer for approval.

PART 2 - PRODUCTS

2.1 DIFFUSERS, GRILLES, REGISTERS AND ACCESSORIES shall be the products of Metal*Aire, Carnes, Price, Titus, or Tuttle & Bailey.

2.2 ONE MANUFACTURER'S products shall be used for like components throughout the work. Do not mix manufacturers without the prior written approval of the Owner's representative or unless required to comply with product specifications and performance criteria.

2.3 PRODUCT MODEL NUMBERS, types, sizes, styles, accessories and other details shall be as scheduled on the Drawings.

PART 3 - EXECUTION

3.1 COORDINATE with General Contractor for all openings and penetrations required in building construction for air outlets and inlets, prior to the construction of work to be penetrated.

3.2 SURFACE MOUNTED OUTLETS AND INLETS: Fit surface mounted outlets and inlets tight against the surface on which they are mounted with no perceivable gaps between the outlet or inlet and the mounting surface and gasket of the grille, register, or diffuser.

3.3 INSTALL OUTLETS AND INLETS level and plumb with building surfaces. Fasten securely to the adjacent structure or surface as recommended by the manufacturer with matching tamper-proof fasteners.

3.4 INSTALL EXTRACTORS behind grilles with adjustment rods and locking screws so extracted air volume can be adjusted by removal of grilles.

3.5 INSTALL EXTRACTORS at branch ducts with adjustment rods extending through duct wall and insulation to setscrew collar.

3.6 PROVIDE T-bar panels as required to match standard lay-in ceiling modules.

3.7 INSTALL minimum 1-1/2" thick fiberglass blanket insulation with vapor retarder jacket

securely taped to the backside (plenum side) of all supply diffusers installed in lay-in ceiling assemblies to prohibit the formation of condensate on the diffuser face.

3.8 INSTALL fire dampers behind sidewall grilles installed in rated walls. Refer to Drawings and Air Distribution Schedule.

3.9 PROVIDE ceiling radiation dampers for inlets and outlets as scheduled on the Drawings.

END OF SECTION

SECTION 23 62 46
VARIABLE REFRIGERANT FLOW UNITS

PART 1 – GENERAL

1.1 SYSTEM DESCRIPTION

A. The outdoor unit shall consist of one or more frames connected through common refrigerant piping and control communication wiring. Each system shall have single or multiple, inverter compressor(s). Each system shall be connected to multiple indoor units (ducted, non-ducted or mixed combinations) through a common refrigerant piping network and integrated system controls and communication network. Each indoor unit shall be controlled individually or as a group. Additionally, heat recovery systems shall be capable of simultaneous heating and cooling of individual zone(s).

B. Simultaneous heating/cooling (heat recovery) systems shall consist of an outdoor unit, BC (Branch Circuit) Controller (or comparable branch devices), multiple indoor units, and an integral DDC (Direct Digital Controls) system. Each indoor unit or group of indoor units shall be capable of operating in any mode independently of other indoor units or groups. System shall be capable of changing mode (cooling to heating, heating to cooling) with no interruption to system operation. To ensure owner comfort, each indoor unit or group of indoor units shall be independently controlled and capable of changing mode automatically when zone temperature strays 1.8 degrees F from set point for ten minutes.

C. The VRF manufacturer shall provide published outdoor unit performance data in table format which states the products heating and cooling capacity expressed in British thermal units per hour (Btuh) and power consumption expressed in kilowatts (kW) at a minimum of 8 possible combinations of allowed conditions between 50% and 130% connection ratio. Possible combinations of allowed condition variables include Combination Ratios expressed as a percentage value, Outdoor Ambient Temperature expressed in degrees Fahrenheit (°F), and indoor unit Entering Air wet and dry bulb temperature expressed in degrees Fahrenheit (°F). Any product whose system design and engineering manuals or guides where published data tables are expressed in units other than these specified will not be accepted.

1.2 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.

B. All wiring shall be in accordance with the National Electric Code (NEC).

C. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

D. Mechanical equipment for wind-born debris regions shall be designed in accordance with ASCE 7-2002 and installed to resist the wind pressures on the equipment and the supports.

E. The condensing unit will be factory charged with R410A.

1.3 SUBMITTALS

A. A complete submittal package shall be compiled and forwarded to the general contractor who shall supply the architect with the submittals for dissemination to all parties. The submittal shall be a collection of documents that represent the technical aspects of each product or collection of products to be used on the project. All performance submissions shall be calculated at the design temperatures; nominal performance data shall not be allowed. The submission and approval of said submittals does not relieve the contractor of supplying all requirements set forth in the specification and drawings. Any substitutions offered by the contractor shall include, as a separate document, any and all differences between the submitted products and the specified products including but not limited to, all dimensions, electrical, control, weights, warranties, country of origin and a statement from the manufacture that no child labor has been used in the manufacture or assembly of said products and a copy shall be supplied with the product outdoor unit submittal.

B. If submittals contain any proposed alternate equipment specifications, calculations, dimensions, electrical specifications, sound specifications or any other mandated submission which are not accepted, are noted or rejected for any reason the contractor shall be allowed to correct any deficiency and re-submit a second time. Should there be any issues found on second submission the contractor will be directed to and agrees to submit on the original specified products and provide the specified products without any additional compensation.

C. Upon job completion: Provide the owner with a copy of approved submittal, VRF system service diagnostics software, project mechanical and control drawings, all as-built piping drawings, O&M's, troubleshooting guides, service manuals and engineering manuals in PDF format.

1.4 DELIVERY, STORAGE AND HANDLING

A. Unit shall be stored and handled according to the manufacturer's recommendations.

PART 2 – WARRANTY

2.1 LIMITED WARRANTY

Manufacturer shall warrant products (the "Products") will be free from defects in material or workmanship. This warranty applies to parts only and is limited in duration to one (1) year from the date of original installation.

2.3 EXTENDED WARRANTY

For compressors only, the manufacturer shall provide the above warranty (which is applicable to parts only) for a five (5) year period. This extended warranty for

compressors is limited in duration to five (5) years from the date of original installation, and applies to the compressor and compressor parts only.

2.3 INSTALLATION REQUIREMENTS

The system must be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents.

PART 3 – PERFORMANCE

3.1 DESIGN BASIS

A. VRF systems shall be Daikin, Mitsubishi or Hitachi. All bidders shall furnish the minimum system standards as defined by the base bid model numbers, model families or as otherwise specified herein. The contractor shall be responsible for all specified items and intents of this document without further compensation.

PART 4 – PRODUCTS

4.1 CONDENSING UNIT

VRF Heat Pump Outdoor Unit shall be capable of continuous compressor operation between the following operating ambient air conditions, operation outside of these conditions are possible and may involve non-continuous operations.

A. Cooling: 14°F DB to 122°F DB
B. Heating: -13°F WB to 61°F WB
C. Cooling based synchronous: 14°F DB to 81°F DB
D. Heating-based synchronous: 14°F WB to 61°F WB

General features:

A. The air-conditioning system shall use R410A refrigerant.
B. The system shall be capable of an automatic refrigerant charge function for use in both the heat mode and cool mode to ensure the proper amount of refrigerant is installed into the system.
C. Each system shall consist of one, two or three air source outdoor unit modules conjoined together in the field to result in the capacity specified elsewhere in these documents.
D. Dual and triple frame configurations shall be field piped together using manufacturer's designed and supplied Y-branch kits and field provided interconnecting pipe to form a common refrigerant circuit.
E. System shall employ self-diagnostics function to identify any malfunctions and provide type and location of malfunctions via fault alarms.
F. Refrigerant circuit configuration for Heat Recovery System
   (i) The refrigerant circuit shall be constructed using field provided ACR copper, de-hydrated, piped together with manufacturer supplied Heat Recovery unit(s) and Y- branches connected to multiple (ducted, non-ducted or mixed combination) indoor units to effectively and efficiently control the simultaneous heating and cooling operation of the VRF system. Other pipe materials shall not be allowed.
G. Each refrigerant pipe, y-branches, elbows and valves shall be individually insulated with no air gaps. Insulation R-value (thickness) shall not be less

than the minimum called for by the local building code, local energy code or as a minimum per manufacture installation requirements. In no case shall the insulation be allowed to be compressed at any point in the system.

(ii) All joints shall be glued and sealed per insulation manufactures instructions to make an air tight assembly.

H. Factory installed microprocessor controls in the outdoor unit(s), HR unit(s), and indoor unit(s) shall perform functions to optimize the operation of the VRF system and communicate in a daisy chain configuration between outdoor unit and HR unit(s) and indoor unit(s) via RS485 network. Controls shall also be available to control other building systems as required from the VRF control system. DIO/AIO capabilities shall be available as well as a central controller to perform operation changes, schedules and other duties as required by this specification. Addition of separate building control system shall not be required. Other control devices and sequences shall be as specified in other sections of this project specification.

I. Inverter PCB cooling: cooling of the inverter PCB shall be conducted by way of passive heat transfer via "Heat Pipe" technology and/ or highly conductive sink method to the outdoor ambient for dissipation to the ambient via natural convection and also by way of forced convection when the outdoor condenser fans are running. Additional cooling of the inverter PCB using mechanical devices other than an existing condenser fans shall not be allowed. Further, use of outdoor coil space or sections to cool inverter PCB shall not be permitted.

J. Compressor control: Fuzzy control logic shall establish and maintain target evaporating temperature (Te) to be constant on cooling mode and condensing temperature (Tc) constant on heating mode by Fuzzy control logic to ensure the stable system performance.

K. Flexible Capacity Control: (Demand limiting) The system shall allow for up to 5 steps of flexible capacity control using an I/O controller or up to 8 steps of flexible capacity control using a BMS control by others. This FCC shall be employed when electrical demand limiting, night time noise reduction or any other flexible capacity control requirement based on any other requirement using contact closures to engage.

L. Initial Test Run (ITR) (Heating) / Fault Detection Diagnosis (FDD) Code: this control mode shall monitor and display positive or negative results of system initial startup and commissioning. It shall monitor the following but not limited to refrigerant quantity charge, auto-charge, stable operations, connection ratios, indoor unit status, error status, number of indoor units connected. This control mode shall not replace the system error monitoring control system.

M. Integration Each system shall be able to integrate via open protocol via BACnet IP.

N. Smart load control: Smart load control operation shall be available at any time during or after system commissioning.

O. Smart load control shall be initiated by outdoor air temperature and shall automatically adjust the evaporator target (condenser target for heat) pressure / temperature that the system will operate to in order precisely load match the system to the building load as the outdoor ambient increases or decreases, by varying the compression ratios of the system and increase the operating efficiencies by adjusting the compressor lifts.

The system shall poll all indoor units' data in real time and apply its algorithm to determine the optimal evaporating temperature to satisfy varying loads. Systems that rely on the worst performing zone to reset the system conditions shall not be sufficient and shall not be allowed.

P. WiFi communication: The outdoor unit shall be WiFi enabled and capable. WiFi shall allow service or maintenance personal access to the complete operating system without need of tools other than smart phone or tablet. Active live system review, collection of all system data for a field determined duration presented in a .csv file format or Collection of all operating conditions, including all indoor units, valves, sensors, compressor speeds, refrigerant pressures, etc. by snapshot of conditions and placing that snapshot into a power point slide to be reviewed at another time. Systems that require computers, hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

Q. Indoor unit connectivity: The system shall be designed to accept connection up to 64 indoor units of various configuration and capacity, depending on the capacity of the system.

R. Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.

S. Connection Ratios: The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50% and no more than 130% of outdoor unit's nominal capacity.

T. The outdoor unit refrigerant circuit shall employ for safety a threaded fusible plug.

U. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor(s), controls, contacts, relay(s), fans, power and communications wiring as necessary.

V. Each outdoor unit refrigeration circuit shall include, but not limited to, the following components:
    1. Refrigerant strainer(s)
    2. Check valve(s)
    3. Inverter driven, medium pressure vapor injection, high pressure shell compressors
    4. Heat pipe cooled inverter PCB
    5. Oil separator(s)
    6. Accumulator(s)
    7. 4-way reversing valve(s)
    8. Vapor injection valve(s)
    9. Variable path heat exchanger control valve(s)
    10. Oil balancing control
    11. Oil Level sensor(s)
    12. Electronic expansion valve(s)
    13. Sub-cooler (s)
    14. High and low side Schrader valve service ports with caps.
    15. Service valves

Refrigerant Flow Control

A. System shall have a variable flow and path outdoor heat exchanger function to vary the refrigerant flow and volume and path. Control of the variable path circuits shall be based on system operating mode and operating conditions as targeted to manage the efficiency of the system.
B. System shall have a medium pressure gas vapor injection function employed in the heating mode to increase system capacity when the outdoor ambient temperatures are low. The compressor vapor injection flow amount shall be controlled by the VI sub-cooling algorithm reset by discharge gas temperatures of the compressor.
C. System shall have an active refrigerant control and multi section accumulator that dynamically changes the volume of refrigerant circulating in the system based on operating mode and operating conditions to ensure maximum system efficiency.
D. The compressor design shall be of the high pressure shell scroll type where the internal pressure below the suction valves of the compressor shall be same as discharge pressure. The motor shall be cooled by high pressure gas and as a result oil shall be stable and non-foaming increasing the efficiency of the system.
E. The VRF outdoor unit shall include a factory provided and mounted sub-cooler assembly consisting of a double spiral tube-type sub-cooling heat exchanger and EEV providing refrigerant sub-cooling modulation control by fuzzy logic of EEV and by mode of operation to provide capacity and efficiency as required
F. System shall have following frame configurations vs. capacity.
    i. 6 to 14 ton units shall be a single frame only.
    ii. 16 to 28 ton units shall be dual frame only.
    iii. 30 to 42 ton heat recovery units shall be triple frame only

Field Supplied Refrigerant Piping Design Parameters

A. The outdoor unit shall be capable of operating at an elevation difference of up to 360 feet above or below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.
B. The outdoor unit shall be capable of operating with up to 3280 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
C. The outdoor unit shall be capable of operating with up to 656 actual feet or 738 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
D. The piping system shall be designed with pipe expansion and contraction possibilities in mind. If required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. Piping systems must be installed per manufacturer's published guidelines
E. Pipe hanger and supports selected should allow for expansion and contraction of the piping system shall not interfere with that movement.

Defrost Operations

A. The outdoor unit(s) shall be capable of Intelligent defrost operation to melt accumulated frost, snow and ice that may have accumulated on the outdoor unit heat exchanger. The defrost cycle length and

sequence shall be based on outdoor ambient temperatures, outdoor unit heat exchanger temperature, and various differential pressure variables.

B. Defrost Mode Selection: The outdoor unit shall be provided with three field selectable defrost operation modes; Normal, Fast, or Forced.
   1. *Normal Defrost* operation intended for use in areas of the country with mild winter temperatures and light to moderate humidity levels. The strategy minimizes defrost cycle frequency allowing frozen precipitation to build longer in between cycles. Minimum time between defrost cycles shall be 20 minutes. Intelligent Defrost shall choose between split coil/frame and full system methods to minimize energy consumption and cycle time.
   2. *Fast Defrost* operation intended for use in areas of the country that experience adverse winter weather with periods of heavy winter precipitation and extremely low temperatures. This strategy shall maximize the systems heating performance and maintain operational efficiency. When the ambient temperature is above 32°F, Intelligent Defrost shall continue to heat until the discharge temperature declines. At temperatures below 32°F, the time between defrost cycles shall be a minimum of 90 minutes. At temperatures below 4°F, a defrost cycle shall occur every two hours to optimize system heating efficiency.
   3. *Forced Defrost* operation shall be available for the service provider to test defrost operations at any weather condition and to manually clear frozen water from the outdoor coil surfaces.

C. Defrost Method Selection: The outdoor unit shall be provided with two field selectable defrost operation methods; Split Coil/Frame and Full System.
   1. Split Coil/Frame method shall be available when Normal Defrost mode is selected. Split Coil method shall be available on all Heat Pump and Heat Recovery *single-frame* VRF systems. Split Frame defrost shall be available on all Heat Pump and Heat Recovery *multi-frame* outdoor units.
   2. Split Coil method shall remove ice from the bottom half of the outdoor unit coil first for six minutes, then the bottom half for six minutes. Next the bottom coil shall be heated again for an additional three minutes to remove any frozen water that may have dripped onto the lower coil during the top coil defrost operation.
   3. When Split Coil/Frame method is selected, a Full System defrost shall be occur every third defrost cycle to assure 100% of the frozen precipitation has been removed to maintain efficient performance.
   4. Full System method shall be available as a field selectable option. All outdoor units located in areas of the country where large volumes of frozen precipitation are common, the commissioning agent shall select the Full System defrost method.

D. Indoor Unit Fan Operation During Defrost
   1. During partial defrost operation indoor units operating in cooling or dry mode shall continue normal operation.
   2. During partial defrost operation, indoor units that are commissioned with fans set for continuous operation shall maintain

normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the defrost cycle.

3. During full system defrost operation indoor unit fans will cycle off and remain off during the remainder of the defrost cycle.

Oil Management

A. The system shall utilize a high pressure oil return system to ensure a consistent film of oil on all moving compressor parts at all points of operation. Oil is returned to compressor through a separate oil injection pipe directly into the oil sump. Oil returned to the compressor via the suction port of the compressor shall not be allowed

B. Each compressor shall be provided with an independent centrifugal oil separator, designed to extract oil from the oil/refrigerant gas stream leaving the compressor.

C. The system shall have an oil level sensor in the compressor to provide direct oil level sensing data to the main controller.

D. The system shall only initiate an oil return cycle if the sensed oil level is below oil level target values as determined by the microprocessor.

E. A default oil return algorithm shall automatically initiate the oil return mode if the system detects a failure of the oil sump sensor. A fault code shall be reported by the system.

F. Timed oil return operations or systems that do not directly monitor compressor oil level shall not be permitted.

G. Indoor Unit Fan Operation During Oil Return Cycle

1. During oil return cycle indoor units operating in cooling or dry mode shall continue normal operation.
2. During oil return, indoor units that are commissioned with fans set for continuous operation shall maintain normal fan speed unless the leaving air temperature drops, then the fan speed will be reduced to low speed for the remainder of the oil return cycle.
3. During oil return cycle indoor unit fans will cycle off and remain off during oil return cycle while operating in all modes except 4.07.e.1 and 2.

Cabinet

F. Outdoor unit cabinet shall be made of 20 gauge galvanized steel with a weather and corrosion resistant enamel finish. Outdoor unit cabinet finish shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours. The test report results with photo images shall be included with submittal documentation.

G. The front panels of the outdoor units shall be removable type for access to internal components.

H. A smaller service access panel, not larger than 7” x 7” and secured by a maximum of (2) screws shall be provided to access the following:

1. Service tool connection
2. DIP switches
3. Auto addressing
4. Error codes
5. Main microprocessor
6. Inverter PCB

I. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.

Fan Assembly

A. 6 ton frames shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a vertical air discharge.
B. 8 to 14 ton frames shall be equipped with two direct drive variable speed propeller fan(s) with BLDC motor(s) with a vertical air discharge.
C. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
D. The fan(s) motor shall be equipped with permanently lubricated bearings.
E. The fan motor shall be variable speed with a maximum operating speed of 1050 RPM.
F. The fan shall have a raised guard to help prevent contact with moving parts.
G. The cabinet shall have option to redirect the discharge air direction from vertical to horizontal with the addition of optional factory provided air guides.
H. The fan controller shall have a DIP switch setting to raise external static pressure of the fan up to 0.32 in-wg to accommodate ducted installations.
I. The fan control shall have a function setting to remove excess snow automatically.

Outdoor Unit Coil

A. Shall be comprised of aluminum fins mechanically bonded to copper tubing.
B. The copper tubes shall have inner riffling to expand the total surface of the tube interior.
C. The aluminum fins shall have factory applied corrosion resistant GoldFin™ material with a Hydrophilic top coat.
D. Coil coating shall be tested in accordance with ASTM B-117 salt spray surface scratch test (SST) procedure for a minimum of 1000 hours. The test report results with photo images shall be included with submittal documentation.
E. Shall have multiple circuits designed for path isolation and variable velocity control.
F. Shall be designed, built and provided by the VRF outdoor unit manufacturer
G. The outdoor unit coil, all indoor units and pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or allow field testing at 550 psig shall not be allowed.
H. The outdoor unit coil for each cabinet shall have lanced aluminum fins with a maximum fin spacing of no more than 14 Fins per Inch (FPI). All the outdoor unit coils shall be a minimum of 3 rows consisting of staggered tubes for efficient air flow across the heat exchanger.
I. The cabinet shall have a factory installed coil guard.

Compressor(s)

A. Each 6, 8, 10 ton frames shall be equipped with a single hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressor.
B. 12 and 14 ton frames shall be equipped with dual hermetically sealed, inverter driven, High Side Shell (HSS) scroll compressors.
C. Each inverter driven, HSS scroll compressor shall be capable of operating from 15 Hz up to 150 Hz with control in 0.5 Hz increments in any and all modes (cooling OR heating)
D. Manufacturers that employ speed limiting algorithms designed to limit compressor capacity to lower power amperage draw shall not be permitted.
E. The compressor(s) shall be equipped with a 60 Watt crankcase heater controlled by oil temperature.
F. The compressor shall employ a factory metered charge of Polyvinyl Ether (PVE) oil.
G. The compressor shall be designed for a separate port for oil to be directly returned to the compressor oil sump.
H. The compressor bearing(s) shall have Teflon™ coating.
I. The compressor(s) shall be protected with:
   (i) High Pressure switch
   (ii) Over-current /under current protection
   (iii) Oil sump sensor
   (iv) Phase failure
   (v) Phase reversal
   (vi) Compressor shall be capable of receiving injection of medium pressure gas at a point in the compression cycle where such injection shall allow a greater mass flow of refrigerant at lower outdoor ambient and achieving a higher heating capability.. The VRF outdoor unit shall have published_performance data for heating mode operation down to -13F on both heat pump and heat recovery systems.
J. Standard, non-inverter driven compressors shall not be permitted nor shall a compressor without vapor injection or direct sump oil return capabilities.

Inverter Compressor Controller(s)

A. The VRF outdoor unit shall be provided with a separate inverter compressor controller PCB for each compressor. Inverter compressor controllers that host more than one compressor shall not be accepted.
B. The inverter compressor controller shall be designed and programmed to utilize the entire range of operation of the connected compressor during cooling cycle operation and/or heating cycle operation.
C. Inverter compressor controllers programmed to limit the compressors heating or cooling capacity to reduce or limit power consumption is not acceptable.

Operational Sound Levels

A. Each single frame outdoor unit shall be rated with an operational sound level not to exceed 59.5 dB(A) when tested in an anechoic chamber under ISO 3745 standard at the highest field selectable heating operating modes available. Such documentation shall be presented in all submittals, manufactures who elect to rate their

equipment at other than the highest field selectable conditions shall not be allowed

B. A field setting shall be available to program the outdoor unit to reduce sound levels at night, when desired, to a selectable level while still able to meet building load requirement.

Sensors

A. Each outdoor unit module shall have
(i) Suction temperature sensor
(ii) Discharge temperature sensor
(iii) Oil level sensor
(iv) High Pressure sensor
(v) Low Pressure sensor
(vi) Outdoor temperature sensor
(vii) Outdoor unit heat exchanger temperature sensor

4.2 HEAT RECOVERY UNIT (HRU) (HEAT RECOVERY SYSTEMS ONLY)

General

A. HR unit shall be designed and manufactured by the same manufacturer of VRF indoor unit(s) and outdoor unit(s).
B. HR unit casing shall be constructed with galvanized steel.
C. HR unit shall require 208-230V/1-phase/60Hz power supply.
D. HR Unit shall be an intermediate refrigerant control device between the air source outdoor unit and the indoor units to control the systems cooling and heating operation.
E. HR unit shall be engineered to work with a three pipe VRF system comprising of
(i) High Pressure Vapor Pipe
(ii) Low Pressure Vapor Pipe
(iii) Liquid Pipe
F. HR units' main 3 pipe connections shall be capable of series or parallel pipe configuration.
G. The quantity of HR units that can be piped in series shall be limited to 16.
H. A single string of series piped HR units shall be capable of serving any combination of styles of VRF indoor units with a combined nominal capacity of up to 192MBh.
I. HR unit shall have 2, 3 or 4 ports, each port supporting one or more indoor units with a maximum connected capacity of 54 MBH.
J. Each port shall be capable of operating in cooling or heating independently regardless of the operating mode of any other port on the HR unit or in the system.
K. Each port shall be capable of connecting from 1 to 8 indoor units.
L. Connection to Indoor units totaling greater than 54MBh nominal capacity shall be twinned to two adjacent ports of the HRU using a reverse Y-branch connector supplied by manufacture.
M. HR unit shall be internally piped, wired, assembled and run tested at the factory.
N. HR unit shall be designed for installation in a conditioned environment per specifications.
O. HR unit shall employ a liquid bypass valve.

P. HR unit shall have (2) two-position refrigerant valves per port.
Q. HR unit shall have a balancing valve to control the pressure between the high pressure and low pressure pipe during mode switching to minimize any change-over pressure related sounds.
R. HR unit shall employ an electronic expansion valve to ensure proper sub cooling of the refrigerant.
S. HRU shall contain one double spiral sub-cooling heat exchanger per port.
T. HR unit shall not require a condensate drain or connection.
U. HR unit shall be internally factory insulated.
V. All field refrigerant lines between outdoor unit and HR unit and from HR unit to indoor unit shall be field ACR tubing, insulated per building or energy code and as instructed by the manufacture.
W. The HR unit shall not exceed a net weight of 50 lbs.
X. HRU's shall not exceed a maximum equivalent pipe length of 8.2 feet.
Y. The VRF manufacturer shall provide published documentation that specifically allows the installation of field provided isolation valves on all pipes connected to the Heat Recovery unit to allow the servicing of HR units, refrigerant circuit or the replacement of HR unit without evacuating the balance of the piping system.

Piping Capabilities

A. The elevation difference between indoor units on heat pump systems shall be 131 feet.
B. The elevation differences for heat recovery systems shall be:
(i) Heat recovery unit (HRU) to connected indoor unit shall be 49 feet
(ii) HRU to HRU shall be 49 feet
(iii) Indoor unit to indoor unit connected to same HRU shall be 49 feet
(iv) Indoor unit to indoor unit connected to separate parallel piped HRU's shall be 131 feet.
C. The acceptable elevation difference between two series connected HR units shall be 16 feet.

Controls

A. HR unit(s) shall have factory installed unit mounted control boards and integral microprocessor to communicate with other devices in the VRF system.
B. HR unit shall communicate with the indoor units via a 2-conductor shielded communications cable terminated using a daisy chain configuration. (see instructions regarding the termination of the shield)
C. The contractor is instructed to review the Electrical and ATC drawings and specifications for other items or tasks which this contractor is or may be responsible to provide materials and or labor under this contract. Failure to do so will not relieve this contractor of their responsibility to provide such materials and or labor and in no case shall this contractor be further compensated as a result.

4.1 INDOOR UNITS

General

A. Nominal cooling capacity ranges from 5,300 Btu/h to 96,000 Btu/h (model dependent) shall be factory assembled, wired, piped and run tested.

B. All indoor units shall be available as ducted, ductless or a combination of both, and shall be complete with factory mounted controls, fans, coils, electronic expansion valves (EEVs), condensate drain pans, condensate drain lift pumps (selected models) filter racks, return air temperature sensors, refrigerant pipe temperature sensors and wiring terminal blocks. The units shall have multiple-speed constant-flow fan assemblies with direct drive digitally commutated BLDC motors.

C. All indoor units shall be capable of real-time response and communication from smart load control and/or flexible capacity control commands and re-set as required super-heat, sub-cooling, sensible heat ratio, total coil capacity and fan control when requested by main processor Indoor units shall provide capacity verses implied load status information.

D. All indoor units shall be factory equipped with a single set of configurable dry contacts for use with integration of other controls, control of remote devices or to be controlled by other devices.

E. All indoor unit coils shall pressure tested with dry nitrogen to a minimum of 500 psi in the field, coils and indoor units containing coils not rated for 500 psi or more shall not be permitted.

F. The entirety of this indoor unit specification and unit options define the minimum acceptable VRF indoor unit requirements for this project. All indoor units provided shall include all features and capabilities.

END OF SECTION

SECTION 23 74 33
OUTSIDE AIR UNITS

PART 1 - GENERAL

1.1 CONTRACT DOCUMENTS: The Contract Documents apply to this section.

1.2 RELATED WORK: Related work specified elsewhere includes:

A. Section 23 0010 - Mechanical General Provisions

1.3 SUMMARY:

A. Outside air units shall meet the capacity and operating conditions indicated on the Design Drawings.

B. Each unit shall be tagged at the factory with its specific location on the job, including building floor, room/area served, and the unit designation shown on the Drawings.

C. All materials and equipment shall be asbestos free.

D. Unit performance shall be as scheduled on the Design Drawings.

E. All electrical components shall bear the U.L. label and shall be listed by Underwriters' Laboratories.

F. All components and work shall meet the applicable standards and codes by references included herein.

G. Units shall be manufactured in the United States of America.

1.4 REFERENCES:

A.	Air Conditioning and Refrigeration Institute	AHRI
B.	American National Standards Institute	ANSI
C.	Air Moving and Conditioning Association	AMCA
D.	American Society for Testing and Materials	ASTM
E.	American Society of Heating, Refrigeration & Air Conditioning Engineers	ASHRAE
F.	American Society of Mechanical Engineers	ASME
G.	American Welding Society	AWS
H.	Anti-Friction Bearing Manufacturers Association	AFBMA
I.	Commercial Standards	CS

J.	Factory Mutual Corporation	FM
K.	Industrial Risk Insurers	IRI
L.	Manufacturers' Standardization Society of the Valve & Fittings Industry (Standard Practice)	MSS SP
M.	National Electrical Code (NFPA 70)	NEC
N.	National Electrical Manufacturer's Association	NEMA
O.	National Fire Protection Association	NFPA
P.	Sheet Metal & Air Conditioning Contractors National Association	SMACNA
Q.	Steel Structures Painting Council	SSPC
R.	Underwriters Laboratories	UL
S.	United States Standard	USS

1.5 QUALITY ASSURANCE:

A. The manufacturer shall be regularly engaged in the manufacture of these components and shall have published complete catalog data on all products offered.

B. The manufacturer shall have been engaged in the manufacture of products offered for not less than five (5) years.

C. Fans shall have certified capacity, static pressure, fan speed, brake horsepower, and selection procedures in accordance with AMCA standards.

D. Refrigeration unit shall have certified capacity in accordance with ARI standards.

E. The unit shall be factory tested prior to shipment.

1.6 SUBMITTALS:

A. Equipment shop drawings shall be submitted for each equipment layout, showing plans and sections of proposed arrangement and size of each unit, including maintenance access, coil removal spaces, duct routing, structural clearances and the like. These shop drawings shall be submitted for approval, as required by Section 23 0010, regardless of manufacturer and equipment selected. Submit the following for approval in accordance with Section 23 0010:

1. Drawings indicating components, dimensions, weights and loadings, required clearances, location and size of all field connections, and assembly details for individual sections.

2. Product data indicating rated capacities, weights, accessories, vibration isolation components, electrical requirements, finishes of materials, and performance criteria for individual sections.

3. Complete sound performance data at design conditions (determined in accordance with ARI and AMCA Standards). Submit sound power ratings in decibel levels referred to 10^{-12} watts obtained in accordance with AMCA Bulletin 300 "Test Code for Sound Rating Air Moving Devices" for each individual unit at the specified performance.

4. Motor data indicating voltage, phase, frame size, RPM, efficiency, power factor and test results.

5. Fan performance data and fan curves indicating capacity, static pressure, fan speed, brake horsepower, plotted selection point, fan curve surge region and minimum capacity.

6. All equipment and component warranties.

7. Manufacturer's installation instructions.

8. Operation and Maintenance manuals to include manufacturer's descriptive literature, start-up and operating instructions, maintenance procedures and parts lists.

B. The manufacturer shall guarantee all units, components and performance data to meet or exceed the specified performance requirements.

C. Submit factory test report indicating all components and controls have been tested prior to unit shipment.

1.7 IDENTIFICATION:

A. Each unit shall be tagged at the factory with its specific location on the job, including location and the unit designation shown on the Drawing.

B. Provide nameplate on each unit and module as required by Section 23 0553 - Mechanical Identification.

1.8 WARRANTY:

A. Manufacturer shall provide a five year parts and labor warranty on each entire unit from date of final acceptance under provisions of Section 23 0010.

1.9 DELIVERY, STORAGE AND HANDLING:

A. Products shall be delivered to the site under provisions of Section 23 0010.

B. Products shall be stored and protected under the provisions of Section 23 0010.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish. Units

damaged by weather, construction activities, or mishandling shall be replaced at the Contractor's expense.

D. Any insulation that becomes wet due to exposure to weather shall be completely replaced. If units are double wall construction, the entire unit shall be replaced.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

A. Acceptable manufacturers are Valent, Greenheck, or Trane approved equal, provided such equipment meets or exceeds the specifications and the scheduled performance requirements and will fit in the available space.

2.2 FANS:

A. Fan shall be double width, double inlet, backward inclined blade, or airfoil centrifugal or plenum type. (Fans with forward curved blades are unacceptable.) The fan shall be Class I or Class II. Fan performance shall be in accordance with AMCA 211 and 311 and comply with the requirements of AMCA Certified Rating Program. Fans shall bear the AMCA seal.

B. Inlet cones shall be spun or die formed.

C. Fan and drive shall be mounted on a spring-isolated structural base inside the fan housing. Spring mounts shall have a minimum 2" deflection rating. The fan housing shall be secured to the discharge opening panel with spring thrust restraints. Fans shall be internally isolated from the unit casing duct connection.

D. Fan housing shall be fabricated of minimum 16 gage thickness galvanized steel and include internal flexible connections on all units.

E. Fan wheels shall be fabricated of steel and painted with a minimum of one shop coat of zinc-chromate primer paint and one coat of galvanized enamel finish after fabrication.

F. Fan wheels and sheaves shall be keyed and fastened to the shafts with set screws.

G. Shafts shall be of steel, either solid or hollow, and ground and polished to tolerance on working surfaces.

H. Nonworking surfaces of shafts shall be coated with factory applied corrosion-proof coating.

I. Bearings shall be anti-friction type, self aligning, grease lubricated pillow-block ball bearings with lubrication fittings, and designed to prevent leakage of lubricant and entrance of dirt.

J. Design life shall be a minimum (not average) of 80,000 hours at the maximum operating speed.

K. Extend grease fittings to the casing door when bearings are located internally.

L. Prior to shipment, statically and dynamically balance fans on their own shafts in their own units at design speed.

M. Provide motor horsepower necessary to drive the fan at the air volume and static pressure scheduled on the Drawings plus 10 percent belt loss. Fan and motor shall be non-overloading at any point on the operating curve, not including motor service factor.

N. Fan shall be electric motor driven through a high capacity type V-belt drive.

O. Drives shall be protected with a belt guard of expanded metal wire mesh, or solid metal side panels with tachometer opening at motor and fan shafts. Shafts shall be drilled to receive tachometer.

P. Provide adjustable motor base and fixed pitch multiple-belt drive. Variable pitch drive pulley may be used on 30HP and smaller motors.

Q. The entire fan drive (sheaves, belts, keys and other items) shall be manufacturer rated at a minimum of 1.5 times the maximum horsepower required to drive the fan.

R. Fans and shafts shall be designed to operate without passing through the first critical speed.

2.3 UNIT CASINGS:

A. Walls and roof shall have an 18 gauge galvannealed steel outer skin with a 22 gauge inner liner except coil section shall be 22 gauge minimum thickness aluminum. Two inch, 1.5# density fiberglass insulation shall be secured between the inner and outer skins. All roof and side wall seams shall be positively sealed to prevent water and air leakage. All bolts and sheet metal screws that penetrate the unit casing shall be gasketed. Total casing air leakage shall not exceed 1-1/2% of rated air flow at 125% of maximum operating pressures.

B. Unit walls and roof shall be constructed of panels with special end flanges for maximum rigidity and minimum thermal bridging at joints. Tubular frame type construction shall not be accepted due to excessive thermal bridging at panel joints and associated potential for condensing moisture on exterior of unit casing.

C. Floors shall be constructed of 16 ga. aluminized steel, with continuous insulation. Insulation shall cover entire floor of unit, leaving no exposed metal for condensation to occur, and shall have a minimum insulating value of R8. Floors to have upturned flange around entire perimeter and around all interior chases to contain moisture within the unit. Multiple floor drain tubes shall be provided to route moisture to side drain connections. All drains and associated piping are to be fully welded and tested. Entire exterior of unit shall be painted with two coats corrosion and weather-resistant 100% acrylic latex paint.

D. Access shall be provided for inspection/maintenance of fans, motor & drives, filters, coils, drains, and all control components. Access doors shall be gasketed, insulated, double-wall constructed with heavy duty stainless steel hinges for rigidity and air tight enclosure.

E. Drain pan shall be continuously welded stainless steel with external condensate connection not less than one inch (1") pipe size. Drain pan shall be sloped to drain and thermally isolated from the unit casing with 1" insulation. All parts of the drain pan exposed to the air stream shall be protected with an antimicrobial coating to proclude growth and dissemination of micro-organisms.

F. The base of the package shall be an all welded structural "C" channel steel frame, and shall be painted with one coat of metal primer, followed by two coats corrosion resistant 100% acrylic latex paint. The frame shall have sufficient cross members to support the system without bending or deforming the casing to maintain waterproof integrity and proper equipment alignment. Lugs for lifting the unit shall be an integral part of the structural frame.

2.4 ENTHALPIC WHEEL (WHERE SCHEDULED):

A. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.

B. Latent and sensible energy transfer shall be provided through a enthalpy wheel, with a minimum total energy recovery effectiveness of 50% tested and certified to AHRI 1060-2005.

C. The heat exchanger frame shall be constructed with extruded 6063 aluminum rails.

D. The wheel shall be capable of handling regular contact with liquid water from either condensation or periodic cleaning while maintaining both the energy recovery effectiveness and 0% EATR rating.

E. The wheel shall be mold and bacteria resistance tested to ISO 846a and 846c with a rating of 0 for both.

F. The heat exchanger core shall comply with UL 723 and have a flame spread index of 25 or less and a smoke index of 50 or less.

G. Stainless steel drain pans shall be provided under entire heat exchanger to catch and drain condensation or water used in periodic cleaning.

2.5 DAMPERS:

A. All dampers shall be of the low leakage airfoil type with blade edge and side seals. Dampers shall be constructed of galvanized steel (14 ga. frames/16 ga. blades) with self-lubricating porous bronze bearings.

B. Outside air and exhaust air dampers shall be provided to prevent infiltration of unconditioned air into the building when the unit is not in operation. Interlock

with unit fan to open when fans are on.

2.6 COOLING COILS: DX type cooling/dehumidification coils shall be sized to provide moisture removal of the capacity indicated on the equipment schedule. Coils shall be fabricated of copper tubes, aluminum fins, galv. steel casings with performance certified by AHRI standards. All coils shall be fully tested for leaks. Coil drain pan(s) shall be fully welded, 16 ga. stainless steel and shall be sloped towards drain lines.

2.7 FILTERS: The supply and exhaust air filters shall be two-inch deep pleated cartridge type, providing an average efficiency of 30 percent by ASHRAE standard 52-75 test method. Filters shall be Farr 30/30 or equal. Face velocity throughout the filters shall not exceed 500 FPM at the unit's rated nominal capacity. Provide one set of filters for use during construction. Install one set of clean filters at completion of construction as directed by the Owner's representative.

2.8 HEATING: Unit shall be provided with AGA-certified, induced-draft, 8:1 turndown indirect gas furnace. Furnace assembly shall include the following items:
Electronic modulating gas valve.
Two-speed combustion fan.
409 stainless steel heat exchanger.

2.9 CONTROLS AND ELECTRICAL COMPONENTS:

A. Provide a unit mounted control panel with terminal block connections for unit controls indicated on the Control Drawings. Panel shall be provided with hinged access doors and mounted on the exterior of the unit in an accessible location.

B. Unit mounted controls for condensing unit shall include, but may not be limited to high refrigerant pressure, low refrigerant pressure to protect against refrigerant loss, and internal overload protection.

C. Electrical components shall be factory wired and include at least the following:

1. Main power distribution block with single point external power connection and disconnect switch for motors and controls and one disconnect for condensing unit.

2. Fused branch circuits for motors and controls and condensing unit.

3. Motor starters with overload protection and terminals for motor control.

4. Main control panel with starters and overloads, branch motor circuit fuses, fused control power transformer, and terminals for interconnecting control wiring (occupied mode, smoke detector safety, unit status, alarm).

5. DDC controls for staging cooling as required to control dewpoint space humidity, and supply air temperature.

6. Outside air and supply air temperature sensors and space humidity transducers shall be furnished with the equipment. Space humidity transducer shall be field mounted and wired by the Controls Contractor.

D. All electrical and control components shall be fully wired and factory tested prior to shipping.

E. All electrical components shall be U.L. listed.

F. Refer to Control Drawings for required controls.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install where shown on the Drawings. Provide required clearances for access, maintenance, and safety.

B. Refer to submittal data for specific dimensional information and installation instructions.

C. Install units on foundations.

D. Units shall be mounted level to ensure proper condensate flow.

E. Support all piping and ductwork independently of the unit to prevent excess noise, vibration transmission, and strain on connections. All connections to unit shall be made with approved flexible connections.

F. Follow specific rigging and installation instructions provided by the manufacturer in the shop drawing submittals.

G. Modules shall be assembled with gaskets between each section and in the order shown in the Contract Documents.

3.2 STARTUP AND TESTING:

A. Provide system preparation, startup, initial testing and placing in service.

B. Provide system testing and balancing per provisions of Section 23 0593.

3.3 EXTRA STOCK:

A. Provide one complete set of spare filters.

B. Provide one set of spare drive belts for each fan section.

END OF SECTION

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.

2. Aluminum building wire rated 600 V or less.

3. Metal-clad cable, Type MC-HCF for Healthcare with ground wire.

4. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.03 DEFINITIONS

A. VFC: Variable-frequency controller.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.01 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

E. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.02 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B 800 and ASTM B 801.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

2.03 METAL-CLAD CABLE, TYPE MC-HCF

A. Description: A factory assembly of one or more current-carrying insulated conductors with redundant grounding provided in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. Comply with UL 1569 and 1063.

3. RoHS compliant.

4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit and multicircuit with color-coded conductors.

2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.

E. Ground Conductor: Insulated.

F. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.

2. Type XHHW-2: Comply with UL 44.

G. Armor: Aluminum, interlocked.

H. Jacket: PVC applied over armor.

2.04 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

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

1. 3M Electrical Products.

2. AFC Cable Systems; a part of Atkore International.

3. Gardner Bender.

4. Hubbell Power Systems, Inc.

5. Ideal Industries, Inc.

6. O-Z/Gedney; a brand of Emerson Industrial Automation.

7. TE Connectivity Ltd.

8. Thomas & Betts Corporation; A Member of the ABB Group.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway Type MC-HCF for Healthcare.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway Type XHHW-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. VFC Output Circuits: Type TC-ER cable with braided shield.

J. Provide Type MC-HCF cable where required by NEC and local codes. Emergency power circuits shall be mechanically protected as specified by NEC 517.30 (C) (3).

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.04 CONNECTIONS

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

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.

b. Test bolted connections for high resistance using one of the following:

1) A low-resistance ohmmeter.

2) Calibrated torque wrench.

3) Thermographic survey.

c. Inspect compression-applied connectors for correct cable match and indentation.

d. Inspect for correct identification.

e. Inspect cable jacket and condition.

f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

g. Continuity test on each conductor and cable.

h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

B. Cables will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports to record the following:

1. Procedures used.

2. Results that comply with requirements.

3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
1) Test wells.
2) Ground rods.

3) Ground rings.
4) Grounding arrangements and connections for separately derived systems.

b. Instructions for periodic testing and inspection of grounding features at test wells based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, by 24” long with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.3 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

J. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
   a. Material: Die-cast zinc alloy.
   b. Listed for direct burial.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 30 inches below grade.

2. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 18 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

G. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

H. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole and shall be at least 12 inches deep, with cover.

1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column extending around the perimeter of building.

1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 30 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Substations and Pad-Mounted Equipment: 5 ohms.

E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Hangers and supports for electrical equipment and systems.

2. Construction requirements for concrete bases.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
   a. Hangers.
   b. Steel slotted support systems.
   c. Trapeze hangers.
   d. Clamps.
   e. Turnbuckles.
   f. Sockets.
   g. Eye nuts.
   h. Saddles.
   i. Brackets.
2. Include rated capacities and furnished specialties and accessories.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit; a part of Atkore International.
   b. B-line, an Eaton business.
   c. ERICO International Corporation.
   d. Flex-Strut Inc.
   e. G-Strut.
   f. Haydon Corporation.
   g. Metal Ties Innovation.

h. Thomas & Betts Corporation; A Member of the ABB Group.
i. Unistrut; Part of Atkore International.
j. Wesanco, Inc.

2. Material: Galvanized steel.
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Hilti, Inc.
      2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) B-line, an Eaton business.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti, Inc.
      4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.

5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

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

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

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

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

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Boxes, enclosures, and cabinets.
5. Handholes and boxes for exterior underground cabling.

1.03 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

PART 2 - PRODUCTS

2.01 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Electri-Flex Company.

4. FSR Inc.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. Southwire Company.
7. Thomas & Betts Corporation; A Member of the ABB Group.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.

2. Coating Thickness: 0.040 inch, minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. FMC: Comply with UL 1; zinc-coated steel or aluminum.

I. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

J. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:
   a. Material: Steel.
   b. Type: Compression.
3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

K. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems; a part of Atkore International.
2. Anamet Electrical, Inc.

3. CANTEX INC.
4. CertainTeed Corporation.
5. Electri-Flex Company.
6. FRE Composites.
7. RACO; Hubbell.
8. Thomas & Betts Corporation; A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

2.03 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.
3. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, 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. Wireway Covers: Hinged type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.04 BOXES, ENCLOSURES, AND CABINETS

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

1. Adalet.
2. Crouse-Hinds, an Eaton business.
3. FSR Inc.
4. Hoffman; a brand of Pentair Equipment Protection.
5. Hubbell Incorporated.
6. Milbank Manufacturing Co.
7. O-Z/Gedney; a brand of Emerson Industrial Automation.
8. RACO; Hubbell.
9. Thomas & Betts Corporation; A Member of the ABB Group.
10. Wiremold / Legrand.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.

1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

M. Gangable boxes are prohibited.

N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.05 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Armorcast Products Company.
   b. Oldcastle Enclosure Solutions.
   c. Oldcastle Precast, Inc.
   d. Quazite: Hubbell Power Systems, Inc.
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.

4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.06 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC.
3. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC.

7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inches of enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each

end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

T. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

U. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.04 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, below grade.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.05 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.06 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.07 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 44
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.

2. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
   b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Advance Products & Systems, Inc.
   b. CALPICO, Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.
   e. Proco Products, Inc.
2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.03 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. HOLDRITE.

2.04 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.05 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.01 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.
B. Comply with NFPA 70.
C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
D. Comply with ANSI Z535.4 for safety signs and labels.
E. Comply with NFPA 70E and Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.
F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.

2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.
b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral: White.

6. Color for Equipment Grounds: Green.

7. Colors for Isolated Grounds: Green with white stripe.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

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

a. Brady Corporation.
b. emedco.
c. Grafoplast Wire Markers.
d. Marking Services, Inc.
e. Panduit Corp.
f. Seton Identification Products.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. Marking Services, Inc.
c. Panduit Corp.
d. Seton Identification Products.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, polyester flexible label with acrylic pressure-sensitive adhesive.

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

a. Brady Corporation.
b. emedco.
c. Ideal Industries, Inc.
d. Panduit Corp.
e. Seton Identification Products.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.

4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm)for raceway and conductors.

b. 3-1/2 by 5 inches (76 by 127 mm)for equipment.

c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

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

a. Brady Corporation.
b. HellermannTyton.
c. Marking Services, Inc.
d. Panduit Corp.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

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

a. Brady Corporation.
b. Panduit Corp.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

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

a. Carlton Industries, LP.
b. Ideal Industries, Inc.
c. Marking Services, Inc.
d. Panduit Corp.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

C. Tape and Stencil: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and is 12 inches (300 mm) wide. Stop stripes at legends.

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

a. HellermannTyton.
b. LEM Products Inc.
c. Marking Services, Inc.
d. Seton Identification Products.

D. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.

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

a. Carlton Industries, LP.
b. Seton Identification Products.

E. Underground-Line Warning Tape:

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

a. Brady Corporation.
b. Ideal Industries, Inc.
c. LEM Products Inc.
d. Marking Services, Inc.
e. Seton Identification Products.

2. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.

b. Printing on tape shall be permanent and shall not be damaged by burial operations.

c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Type:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches (75 mm).
c. Overall Thickness: 5 mils (0.125 mm).
d. Foil Core Thickness: 0.35 mil (0.00889 mm).
e. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
f. Tensile according to ASTM D 882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be [1 inch (25 mm)].

2.6 TAGS

A. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. LEM Products Inc.
e. Marking Services, Inc.
f. Panduit Corp.
g. Seton Identification Products.

B. Write-on Tags:

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

a. Carlton Industries, LP.

b. LEM Products Inc.
c. Seton Identification Products.

2. Polyester Tags: 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment.

3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

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

a. Carlton Industries, LP.
b. Champion America.
c. emedco.
d. Marking Services, Inc.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.

3. 1/4-inch (6.4-mm) grommets in corners for mounting.

4. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Laminated Acrylic or Melamine Plastic Signs:

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2. Engraved legend.

3. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick).

b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.

c. Engraved legend with black letters on white face.

d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting.

e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

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

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).

3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 7000 psi (48.2 MPa).

3. UL 94 Flame Rating: 94V-0.

4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).

5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "LIFE SAFETY BRANCH"

2. "CRITICAL BRANCH"

3. "EQUIPMENT BRANCH"

M. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.

2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

U. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

V. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

W. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

2. Limit use of underground-line warning tape to direct-buried cables.

3. Install underground-line warning tape for direct-buried cables and cables in raceways.

X. Metal Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

Y. Nonmetallic Preprinted Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

Z. Write-on Tags:

1. Place in a location with high visibility and accessibility.

2. Secure using UV-stabilized cable ties.

AA. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

BB. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

CC. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use labels 2 inches (50 mm) high.

DD. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.

2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch- (75-mm-) high, black letters on 20-inch (500-mm) centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 30-foot (10-m) maximum intervals.

D. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

E. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "LIFE SAFETY BRANCH"

2. "CRITICAL BRANCH"

3. "EQUIPMENT BRANCH"

F. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive vinyl tape to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.

H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.

I. Conductors to Be Extended in the Future: Attach write-on tags to conductors.

J. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

K. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

L. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:

1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.

2. Wall surfaces directly external to raceways concealed within wall.

3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

O. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.

2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

a. Power-transfer switches.

b. Controls with external control power connections.

P. Arc Flash Warning Labeling: Self-adhesive labels.

Q. Operating Instruction Signs: Self-adhesive labels .

R. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.

S. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label.

2. Outdoor Equipment: Laminated acrylic or melamine sign.

3. Equipment to Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Emergency system boxes and enclosures.
h. Enclosed switches.
i. Enclosed circuit breakers.
j. Enclosed controllers.
k. Push-button stations.
l. Power-transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Monitoring and control equipment.

END OF SECTION

SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Molded-case switches.
6. Enclosures.

1.03 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and Insert calculation program format electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in [PDF] [and] <Insert calculation program format> electronic format.

1.06 FIELD 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 and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.07 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.02 FUSIBLE SWITCHES

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 600-V ac.
4. 1200 A and smaller.
5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. Service-Rated Switches: Labeled for use as service equipment.

2.03 NONFUSIBLE SWITCHES

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.

2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.

4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.

5. Lugs: Mechanical type, suitable for number, size, and conductor material.

6. Service-Rated Switches: Labeled for use as service equipment.

2.04 MOLDED-CASE CIRCUIT BREAKERS

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

1. Eaton.
2. Siemens Industry, Inc.
3. Square D; by Schneider Electric.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 167 deg F (75 deg C) rated wire.

F. Standards: Comply with UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents.

G. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.

2. Long- and short-time pickup levels.

3. Long- and short-time time adjustments.

4. Ground-fault pickup level, time delay, and I-squared t response.

H. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.

2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.05 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Operating Mechanism: The circuit-breaker operating handle shall be directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

D. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.02 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.

2. Outdoor Locations: NEMA 250, Type 3R.

3.03 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in fusible devices.

F. Comply with NFPA 70 and NECA 1.

3.04 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Overcurrent Protective Device Coordination Study."

END OF SECTION

SECTION 26 51 19
LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.
B. CRI: Color Rendering Index.
C. Fixture: See "Luminaire."
D. IP: International Protection or Ingress Protection Rating.
E. LED: Light-emitting diode.
F. Lumen: Measured output of lamp and luminaire, or both.
G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Arrange in order of luminaire designation.
2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project IES LM-79 and IES LM-80.

a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the

National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.06 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Provide luminaires from a single manufacturer for each luminaire type.

C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.08 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Recessed Fixtures: Comply with NEMA LE 4.

E. Bulb shape complying with ANSI C79.1.

F. Lamp base complying with ANSI C81.61 or IEC 60061-1.

G. CRI of minimum 80. CCT of 3000 K.

H. Rated lamp life of 50,000 hours.

I. Lamps dimmable from 100 percent to 0 percent of maximum light output.

J. Internal driver.

K. Nominal Operating Voltage: As indicted on the drawings.

1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.02 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. 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.

C. Diffusers and Globes:

1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.

b. Lamp diameter, shape, size, wattage, and coating.

c. CCT and CRI for all luminaires.

2.03 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.04 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" 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 luminaire.

C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.03 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.

3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.05 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.07 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION