

**CONTRACT CONDITIONS FOR
HVAC UPGRADES AT
FAIRVIEW FIRE STATION #2
TOWN OF FAIRVIEW, TEXAS**

Project Manual



**ENGINEER
RWB CONSULTING ENGINEERS
12222 MERIT DRIVE, SUITE 400
DALLAS, TEXAS 75251**

**RWB Project No. 23109.00
Issue for Construction
November 3, 2023**

SPECIFICATION INDEX

<u>SECTION</u>	<u>TITLE/DESCRIPTION</u>
00 30 00	BID PROPOSAL FORM
00 40 00	BID PROPOSAL NOTIFICATION
00 50 00	INSTRUCTIONS TO BIDDERS
01 01 00	SUMMARY OF WORK
23 00 00	HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) WORK
23 05 00	COMMON WORK RESULTS FOR HVAC
23 05 13	COMMON MOTOR REQUIREMENTS FOR HVAC
23 05 48	VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT
23 05 53	IDENTIFICATION FOR HVAC DUCTWORK, EQUIPMENT AND PIPING
23 05 93	MECHANICAL SYSTEMS TESTING, ADJUSTING, AND BALANCING (TAB)
23 07 00	INSULATION
23 08 00	MECHANICAL SYSTEMS COMMISSIONING
23 09 00	CONTROLS AND INSTRUMENTATION
23 21 16	CONDENSATE PIPING
23 23 01	VRV/VRF REFRIGERANT PIPING
23 30 00	HVAC AIR DISTRIBUTION
23 43 00	AUTO-CLEANING NEEDLEPOINT BIPOLAR IONIZATION SYSTEM
23 81 28	VARIABLE REFRIGERANT FLOW (VRF) AIR CONDITIONING UNITS
26 00 00	ELECTRICAL
26 05 01	ELECTRICAL DEMOLITION
26 05 19	LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 20	CABLE CONNECTIONS
26 05 23	CONTROL - VOLTAGE ELECTRICAL POWER CABLES
26 05 26	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 29	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 05 32	RACEWAYS
26 05 33	BOXES FOR ELECTRICAL SYSTEMS
26 05 53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 27 16	ELECTRICAL CABINETS AND ENCLOSURES
26 28 16	ENCLOSED SWITCHES AND CIRCUIT BREAKERS

SECTION 00 30 00

PROPOSAL FORM

SUBMITTED BY: _____
(Name of Proposer)

(Address)

Dear Sir:

The undersigned, having examined the drawings, specifications, related documents, and each site of the proposed work which is being bid, and being familiar with all of the conditions surrounding the work, including the availability of materials and labor, hereby proposes to furnish all labor, materials, and equipment required for the following projects at North Lake College for the Dallas County Community College District, in accordance with the project manual prepared by Reed, Wells, Benson and Company, for the lump sum amounts listed below:

A. For all work identified in the contract, provide a base bid proposal to complete all work per the conditions indicated in the Contract Drawings and Project Manual as follows:

BASE BID PROPOSAL: _____ Dollars (\$_____).

State the name of the HVAC Equipment manufacturer upon which the bid is based:

ALTERNATES

The following are alternates to the Base Bid amount listed above. It is understood that if no figure is listed for an Alternate, that the Alternate may be accepted and there shall be no added charge to the corresponding Base Bid amount indicated above. Strike out (add) or (deduct) as required for each alternate.

ALTERNATE NO. 1:

Provide the Added/Deductive Cost to the Base Bid to provide VRF/VRV air conditioning equipment manufactured by **Daikin**, as specified.

_____ Dollars (\$_____).

ALTERNATE NO. 2: NOT USED

Provide the Added/Deductive cost to the Base Bid to provide _____
_____ as shown on the Drawings and as specified.

_____ Dollars (\$_____).

ALTERNATE NO. 3: NOT USED

Provide the Added/Deductive Cost to the Base Bid to provide _____
_____ as shown on the Drawings and as specified.

_____ Dollars (\$_____).

Notes:

1. Amounts shall all be shown in both words and figures. In case of discrepancy, the amount shown in words shall govern.
2. The above amount does not include State of Texas Sales Tax.
3. The Base and Alternate Proposal Work is intended to be performed during normal working hours, except for activities that create excessive noise or causes a disruption in building services. In these instances, work shall be performed only when scheduled through the Owner, after hours, and on weekends. All Base and Alternate Bid work shall be substantially completed by June 10, 2024 unless specifically noted otherwise.
4. The existing building is operational and is required to remain in operation for the duration of the contract. The building will be made to Contractor, and their subcontractors, only after a Notice to Proceed is issued. The building will still be in full use by the Owner.

The undersigned affirms that the above stipulated base Proposal sum for each project represents the entire cost per drawings, specifications, and addenda and that no claim will be made on account of any increase in wage scales, material prices, taxes, insurance, cost indexes, or any other rates affecting the construction industry and/or this project.

The undersigned Proposer agrees that this Proposal shall be good and may not be withdrawn for a period of at least 45 calendar days after the scheduled closing time for receiving Proposals.

The undersigned Proposer understands that the Owner reserves the right to reject any or all Proposals and to waive any informalities in each proposal.

The Owner reserves the right to require Bonds from the successful Proposer. If written notice of acceptance of this Proposal is received within 45 days after date designated for opening of Proposals, the undersigned, within 10 days of receipt of the Contract, will sign and deliver to the Owner the contract and all required Performance, Labor and Material Payment Bonds, along with a properly executed Insurance Verification Form required by the Owner.

Should the undersigned fail to deliver the signed Contract or the required Bonds or Insurance Form within the 10 day period, the Owner reserves the right to terminate the relationship.

Time of completion: The undersigned agrees to commence work under this contract within 10 days of receipt of written notice-to-proceed from the Owner, and to be substantially complete with the mechanical/electrical work of the contract no later than that stated above, and to achieve Final Completion of the entire contract no later than that stated above, unless stipulated otherwise in the Base Proposal choice above.

Proposed Calendar Days to Complete Work after receipt of a Notice to Proceed:
_____ Days

Addenda: The undersigned hereby acknowledges receipt of the following addenda to the Drawings and Specifications, all of the provisions and requirements of which addenda have been taken into consideration in the preparation of this Proposal.

Addendum No. _____ Dated _____

Addendum No. _____ Dated _____

Date: _____ Signed _____

Title _____

Name of Firm _____

Organized as a: (Mark one)

Proprietorship _____

Partnership _____

Corporation _____

Under the law of the State Of:

(Date)

Legal Address:

Telephone No. _____

Fax No. _____

E-mail Address: _____

If Proposal is by a corporation, affix seal above address.

END OF PROPOSAL FORM

TOWN OF FAIRVIEW

NOTICE TO CONTRACTORS

1. Sealed bids (proposals) addressed to the Town of Fairview (Town), 372 Town Place, Fairview, Texas 75069, will be received at Town Hall until 2:00 p.m., Thursday, November 30th, 2023, for

FIRE STATION 2 HVAC UPGRADES

At such time bids will be publicly opened and read aloud.

2. The work consists of furnishing all labor, equipment and materials (except as otherwise specified), and performing all work necessary for the replacement and upgrade of the existing HVAC (Air Conditioning) systems at this facility.
3. Plans and Specifications for the work may be downloaded at www.fairviewtexas.org

TOWN OF FAIRVIEW, TEXAS

Jeff Bell
Fire Chief

INSTRUCTIONS TO BIDDERS

1. Each proposal shall be legibly written or printed in ink, on the proposal form provided in this bound copy of proposed Contract Documents. No alterations in proposal, or in the printed forms thereof, by erasures, interpolations, or otherwise will be acceptable unless each such alteration is signed or initialed by the Bidder; if initialed, the Town may require the Bidder to identify any alterations so initialed. No alteration in any proposal, or in the proposal form on which it is submitted, shall be made by the person after the proposal has been submitted by the Bidder. Any and all addenda to the Contract Documents on which a proposal is based, properly signed by the Bidder, shall accompany the proposal when submitted. The Bidder may withdraw their proposal any time prior to the bid opening date and time stipulated in the Notice to Contractors.

Each proposal submitted shall be enclosed in a sealed envelope, addressed to the Town of Fairview, 372 Town Place, Fairview, Texas 75069, identified on the outside with the words "FIRE STATION 2 HVAC UPGRADES" and identifying the Bidder. Proposals shall be delivered to the Fire Chief by 2:00 p.m., November 28th, 2023, at such time bids will be publicly opened and read aloud. **Facsimile Transmittals Will Not Be Accepted.**

All bids will be tabulated for the Town Council by the Fire Chief. The Town Council will determine the lowest responsible bid, after considering the recommendations of the Fire Chief and RWB Consulting Engineers, determine whether such bid is that of a responsible Bidder, and award a contract to the Contractor determined to be the lowest responsible Bidder. The Fairview Town Council will authorize the Town Manager to enter into a contract with said Contractor.

2. Each Proposal shall be accompanied by either a cashier's check, a certified check, or an acceptable bid bond in an amount of not less than five percent (5%) of the proposed bid price, made payable without conditions to "Town of Fairview, Texas", and the amount of the said proposal Guarantee may be retained by and forfeited to the Town as liquidated damages if the proposal covered thereby is accepted and a contract based thereon is awarded and the Bidder should fail to enter into a contract in the form prescribed, with legally responsible sureties, within the ten (10) days after such award is made by the Town.

The proposal guarantee deposit of the unsuccessful Bidders will be returned if and when their proposals are rejected. The proposal guarantee deposit of the Bidder to whom a contract is awarded will be returned provided, and when, said successful Bidder executes a contract and files satisfactory bonds as hereinafter stipulated. The proposal guarantee deposit of the second and third lowest responsible Bidders may be retained for a period of not to exceed sixty (60) days pending the execution of the contract and bonds by the successful Bidder.

3. Accompanying the proposal, each Bidder shall furnish an experience list of similar work along with such other information as will tend to show the Bidder's ability to prosecute the required work. The Bidder shall have a minimum of three years experience and successful history in the performance of similar work. The Town may make such investigations as they deem necessary to determine the

ability of the Bidder to perform the work. The experience list is not required for those Bidders who have performed similar work for the Town of Fairview within the past 5 years.

4. Each Bidder shall carefully examine the Specifications, and other Contract Documents, shall visit the site and fully inform themselves of all conditions affecting the work or the cost thereof, and shall be presumed to have done so and their bid shall be based upon their own conclusions from such examination. Each Bidder shall inform themselves concerning all Federal, State, and local laws, ordinances or regulations which may in any manner affect their proposed construction operations, or those engaged or employed on the work or the material or equipment. Should a Bidder find discrepancies in, or omissions from, the Plans, Specifications or other Contract Documents, he should at once notify the Town Engineer and obtain clarification or interpretation prior to submitting any bid.

Any interpretation of the proposed Contract Documents will be made only by addendum duly issued and a copy of such addendum will be mailed or delivered to each person obtaining a set of such documents from the Town Engineer. The Town will not be responsible for any other explanations or interpretations of the proposed Contract Documents.

5. Each Bidder to whom a contract for the work is awarded will be required to furnish surety as follows:

Performance Bond: A contract bond to the Town, in an amount equal to 100 percent (100%) of the not to exceed contract price.

Payment Bond: A payment bond to the Town, in an amount equal to 100 percent (100%) of the not to exceed contract price.

The bonds shall be executed in three (3) counterparts on the forms bound herein, signed by an acceptable surety company authorized to do business in the State of Texas as required by Article 5160 V.A.T.C.S.

Attorneys-in-fact who sign the bonds must file with each bond a certified and effective dated copy of their power of attorney.

Certificates of Insurance: Satisfactory certificates of insurance shall be filed with the Town in accordance with the GENERAL CONDITIONS and SUPPLEMENTARY CONDITIONS in the Contract Documents.

6. The Bidder's attention is directed to Texas House Bill 11 (72nd Legislature, 1st C.S.) which amended the Texas Tax Code Section 151.311. This amendment provides that by the CONTRACTOR entering into a separated contract, The CONTRACTOR will become a seller of materials purchased for the project, which will obviate paying taxes, on materials incorporated into the project.

7. No Bidder may submit more than one proposal. Two proposals under different names will not be received from one firm or association.

8. No Bidder may withdraw their proposal for a period of sixty (60) days after the date and hour set for the opening herewith. A Bidder may modify or withdraw their proposal at any time prior to the expiration of the period during which proposals may be submitted, by written request of the same persons or person who signed the Proposal.

9. The Town reserves the right to accept the bid which, in its judgment is the lowest responsible bid; to reject any or all bids; and to waive irregularities or informalities in any bid submitted. Bids received after the specified time of closing will be returned unopened. Conditional or qualified bids will not be accepted.

10. None of the Instructions to Bidders, Proposal, Performance Bond, Payment Bond, Contract Agreement, General Conditions, Special Conditions or Specifications shall be removed from the bound copy of the Contract Documents prior to filing the proposal contained therein.

11. Each Bidder shall sign their proposal, using their usual signature and giving their full business address. Bids by partnerships shall be signed with the partnership name followed by the signature of one of the members of the partnership or by an authorized representative and designation of the person signing. Bids by corporations shall be signed with the name of the corporation, followed by the signature and designation of the president, secretary, or other person authorized to bind it in the matter. The names of all persons signing should also be printed below the signature. A bid by a person who affixes to their signature the word "President", "Secretary", "Agent", or other designation, without disclosing their principal, may be held to be the individual signing. When requested by the Town, satisfactory evidence of the authority of the officer signing on behalf of a corporation shall be furnished.

12. The Notice of Award shall be accompanied by the necessary Contract Agreement and Bond forms. The Bidder to whom the Contract is awarded will be required to execute the Contract Agreement and obtain the Performance and Payment Bonds and Certificates of Insurance within ten (10) calendar days from the date when notice of Award is delivered to the Bidder. In case of failure of the Bidder to execute the Contract Agreement, the Town may at its option consider the Bidder in default, in which case, the bid security accompanying the Proposal shall become the property of the Town.

13. The Town, within ten (10) days of receipt of acceptable Performance Bond, Payment Bond, Certificates of Insurance and Contract Agreement signed by the Bidder to whom the contract was awarded, shall sign the Contract Agreement and return to the Bidder two (2) executed copies of the Contract Agreement. The Bidder may withdraw their signed Agreement should the Town not execute the Agreement within the stated period by written notice to the Town.

14. The Notice to Proceed shall be issued within ten (10) days of the execution of the Contract Agreement by the Town. The time may be extended by mutual agreement between the Town and Contractor. If the Notice to Proceed has not been issued within the specified time or mutually agreed upon extension, the Contractor may terminate the Contract Agreement without further liability on the part of either party.

15. Attention is called to the fact that not less than the federally determined prevailing wage rate, as issued by the U.S. Department of Labor, must be paid on this project.

16. The Town intends to award the Contract to a Bidder that will be doing a substantial portion of the work rather than through subcontracts. The Bidder must complete the item in the Proposal regarding the amount of work to be done by the Prime Contractor. The Town reserves the right to consider this breakdown in awarding the Contract.

17. Each Bidder shall list all subcontractors they propose to use on this project for which the amount of the subcontract is in excess of \$10,000. The list shall include the name and address of the subcontractor, the work they will be performing and the amount of the subcontract. The Bidder shall also complete a Statement of Qualifications and Experience for each subcontractor. The Contractor shall not change subcontractors or enter into contract with subcontractors not listed without prior approval by the Town. The Town reserves the right to refuse any or all requests for changes.

SECTION 01 01 00

SUMMARY OF WORK

PART 1 - WORK COVERED BY CONTRACT DOCUMENTS

- A. The Work of this Contract consists of the furnishing of all labor, materials, services, equipment, and appliances required in conjunction with or properly incidental to the Replacement HVAC VRF Indoor and Outdoor Units at Fire Station #2 (Fairview, Texas) for the Town of Fairview.
- B. The Drawings and Specifications do not necessarily indicate or describe all work required for completion of Project. Contractor shall provide and install all incidentals reasonably inferable from the Contract Documents that are required for a complete Project.
- C. These documents describe the essential elements sufficiently to determine the scope of the Project.
- D. Provide all items required for complete operating systems including items not necessarily shown in these documents, but that can be reasonably inferred as being required for a complete operating system.
- E. The Drawings and Specifications indicate the basic quality of material and quality of construction required for entire Project.

1.2 RELATED REQUIREMENTS

- A. Division 1 - General Requirements of Project Manual governs execution of Specification Sections within Divisions 2 through 28, inclusive.

1.3 WORK SEQUENCE

- A. Construct Work in stages to accommodate Owner's use of premises during construction period. Coordinate construction schedule and operations with Owner's Representative:
 - 1. Do not interrupt any existing utilities without prior approval and coordination.
 - 2. Existing utilities must be maintained and uninterrupted as noted above and in accordance with provisions in Supplementary Conditions to the Contract.
- B. Minimum disruption of Fire Station operation and use of adjacent facilities and access to those facilities is required. Cooperation with Owner to minimize inconvenience is essential.

- C. Construct the Work in stages to provide for public convenience. Do not close off public use of facilities until completion of one stage of construction will provide alternative usage.
- D. Stages of construction are those indicated on Drawings, unless noted otherwise.
- E. Owner may require certain work to be performed after normal working hours or on holidays or weekends. Refer to Supplementary Conditions of the Contract for specific requirements.

1.4 CONTRACTOR'S USE OF PREMISES

- A. Contractor shall have complete use of the immediate premises of the Project site for execution of the Work of this Contract after issuance of notice to proceed.
- B. Coordinate use of premises under direction of Engineer and Owner. Contractor shall be responsible for monitoring the use of premises by Contractor's employees and sub-contractors.
- C. Access routes for delivery of materials and equipment shall be as indicated by the Owner. Do not use access routes other than those indicated without permission of the Owner.
- D. Assume full responsibility for the protection and safekeeping of Products under this Contract, stored on the site. Store materials and products only in those areas indicated for staging.
- E. Move any stored Products, under Contractor's control, which interfere with operations of the Owner or separate contractor, or as required by Engineer. Do not unnecessarily encumber project site with materials and equipment.
- F. Staging and material storage shall be limited to the areas indicated by the Owner. Obtain specific permission from the Engineer for the use of other areas for storage and staging.
- G. Do not overload existing or new structures with weight that would compromise safety. Verify design loads for structure if necessary prior to loading structure.
- H. Obtain and pay for the use of additional storage or work areas needed for operations.
- I. Protect existing lawns, sidewalks, pavements, curbs and utilities subject to damage by work under this Contract. Repair or replace any existing work damaged by the Contractor. Replace existing lawns damaged by Contractor's activities with sod to provide full stand of replacement grass.

- J. Parking areas for Contractor's personnel shall be as acceptable to Owner.

1.5 WORK ON EASEMENTS, R.O.W., AND ADJACENT PROPERTY

- A. Obtain permission from other property Owners, obtain and pay all fees required by applicable governing authorities, prior to commencing with work on easements, right-of-ways, and adjacent property. This also applies to the transport of cranes and other related equipment.
- B. Post all notices and warning signs required by applicable governing authorities.
- C. Perform work on easements, right-of-ways, and adjacent property in accordance with local codes and ordinances and utility company requirements.

1.6 OWNER OCCUPANCY

- A. Cooperate with Owner's Representative in all construction operations to minimize conflict and to facilitate Owner usage.
- B. Contractor shall at all times conduct his operations as to ensure least inconvenience to general public.
- C. Maintain at all times safe access and egress from existing building. Maintain safe exit paths from building for emergency egress.
- D. All construction equipment, materials or work must be adequately fenced and protected.
- E. Any damage or interruption to any of Owner's existing utilities or services described above in Item 1.4 shall be repaired immediately. Contractor shall immediately place an adequate work force at place of disruption to minimize time required for repairs. Contractor shall make every effort to expedite repairs, regardless of cause of damage, or responsibility for damage, to return damaged utility or service to full operation as quickly as possible.

1.7 PARTIAL OWNER OCCUPANCY

- A. Contractor agrees to use and occupancy of Project by Owner prior to Substantial Completion of entire Project.
- B. Use and occupancy prior to Substantial Completion of entire Project does not relieve Contractor of responsibility to maintain specified insurance coverages on 100% basis for benefit of Owner, Contractor and subcontractors until Project is complete and accepted by Owner.

C. Contractor provides for:

1. Access for Owner's personnel.
2. Temporary operation of heating, ventilating, air-conditioning and electrical systems.
3. Access for public to extent allowed by Owner.

D. Operation: During occupancy, mutually acceptable arrangements shall be negotiated between Owner and Contractor regarding warranties and insurance requirements respecting portions of Work affected by partial occupancy and regarding operation and cost of building services so that costs attributable to partial occupancy shall be borne by Owner and costs attributable to performance of Work shall be borne by Contractor.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 23 00 00

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC) WORK

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. The work in this Division covers all HVAC work specified in all Division 23 Specification Sections and as illustrated on the HVAC Drawings. Comply with other Division 23 Specification Sections as applicable. Refer to other Divisions for coordination of work with other trades.
- B. Provide all labor, materials, equipment, transportation, tools and services, and perform all operations required for, and reasonably incidental to, the providing of mechanical system work described in this Division.
- C. Contractor shall include providing instructions and demonstrations of the operation of each installed system in its totality to the Owner. Refer to Division 23 specifications for specific Owner training requirements. As a minimum include training of the Owner's Operating Personnel on:
 - 1. Safety Shut-Down of HVAC Equipment.
 - 2. Sequence of HVAC Equipment Operation.
- D. Operation and Maintenance of all HVAC Equipment.
- E. The Conditions of the Contract, including the General Conditions and Supplementary Conditions, and Division 1 - General Requirements, apply to work covered by this section.

1.2 DESCRIPTION OF HVAC DEMOLITION WORK

- A. Contractor shall remove several items of materials and equipment under this Section of the Specifications. Equipment and materials to be removed shall be as indicated and noted on the Drawings and as required to facilitate the new installations.
- B. Generally, modifications to, replacing of, or making new connections into existing service lines shall be accomplished only during the times directed by the Owner's Representative.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 INSTRUCTION OF OWNER'S PERSONNEL

- A. Prior to Substantial Completion, fully instruct the Owner in the operation, adjustment, and maintenance of products, equipment, and systems; including, but not limited to all HVAC equipment, related accessories and components, temperature controls and the energy management system. Owner shall operate all systems in cooperation with Contractor for a period of at least five (5) working days prior to, or shortly after, Substantial Completion.
- B. Arrange for services of qualified manufacturer's representatives to fully instruct Owner on specialized portions of installations, such as air handling units and auxiliaries; VAV terminal units, automatic temperature controls, and water treatment systems.
- C. Arrange for each installer of equipment that requires regular maintenance to meet with Owner to provide instruction in proper operation and maintenance. If installers are not experienced in procedures, provide instruction by trained manufacturer's representatives. Include detailed review of the following items:
 - 1. Operating and Maintenance Manuals.
 - 2. Record Documents.
 - 3. Spare Parts and Materials.
 - 4. Lubricants.
 - 5. Cleaning.
 - 6. Standard and Extended Warranties.
 - 7. Maintenance Requirements, Agreements, and similar continuing commitments.
- D. As a part of these instructions for operating equipment, demonstrate the following procedures:
 - 1. Start-Up.
 - 2. Shut-Down.
 - 3. General System Operating Instructions.
 - 4. Emergency Operating Conditions.
 - 5. Noise and Vibration Adjustments, where applicable.
 - 6. Safety Procedures.
 - 7. Economy and Efficiency Adjustments.
 - 8. Effective Energy Utilization.
- E. Return at first change of season for changeover from air conditioning to heating, or from heating to air conditioning, to demonstrate system operation in the opposite season.

- F. Submit a complete record of instructions as a part of maintenance instructions and the data book (Operations and Maintenance Manual) given to Owner. For each instructional period, supply the following data:
1. Date of Instruction.
 2. System or Equipment Involved.
 3. Names of Persons Giving Instructions.
 4. Other Persons Present.
 5. Time Period (in hours/minutes) Instruction Provided.
- G. Amount of time to be devoted to instructional sessions shall be reasonable and consistent with the size and complexity of equipment and systems installed and as specified in other sections of these specifications.

3.2 TEMPORARY WORKING ACCESS

- A. Each respective trade shall remove existing piping, equipment, fixtures, and other items to provide access for work in existing facilities and on the site. Contractor shall seek Owner's Representative approval prior to removal of any equipment and mechanical appurtenances.
- B. Reinstall and refinish items removed, or otherwise damaged, to match existing adjacent surfaces, or new finishes where applicable, upon completion of the work.

3.3 DISRUPTION OF EXISTING FUNCTIONS

- A. Access: Access to and use of the existing facilities and site will be restricted, and shall be under the direction and control of the Owner.
- B. Disruptions: Maintain existing mechanical, and other existing systems, and maintain all existing functions in service except for those specific portions scheduled for disruption. Where existing functions to remain in use are disrupted, they shall be fully restored after disruption, in full compliance with this Division of the Specifications for new work, as quickly and as reasonably possible.
- C. Scheduling of Disruptions: Seek and obtain approval by the Owner two (2) weeks in advance of each event. Failure to schedule such disruptions in advance will result in the Contractor being stopped or rescheduled by the Owner without added cost to the Owner.
- D. Notice of Disruption: Date, time and duration of each disruption shall be subject to the Owner's prior written approval and shall include the following information in the form of a memorandum submitted by the Contractor to the Owner's Representative for approval by the Owner:

Facility/System	Date	Starting Time	Duration
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- E. Emergency Disruptions: When circumstances preclude obtaining advance approval as specified above; make request immediately on knowledge of the requirement, and perform the work so as to cause the minimum amount of disruption, for the minimum duration.
- F. Notification: Notify the Owner's Representative and the Owner immediately, by telephone and then in writing, as changes and additions to the scheduled disruption requirements become known.
- G. Duration:
 - 1. Complete as large a portion of the work as possible before initiating disruption.
 - 2. Maintain adequate personnel, supplies, materials, equipment, tools, and other resources at job site to avoid unnecessary delay in resumption of normal services.
 - 3. Keep duration of disruption as short as possible.
 - 4. During the disruption, perform only the amount of work that requires the disruption, so as to minimize duration of disruption.

3.4 MODIFICATIONS AND RELOCATIONS

- A. Modify, remove, or relocate materials and items indicated on the Drawings or required by the installation of new facilities.
- B. Relocations:
 - 1. Repair and restore to good functional condition, equipment, materials and items scheduled for relocation, which are damaged during dismantling or reassembly operations.
 - 2. Remove carefully, in reverse order to original assembly or placement, items which are to be relocated.
 - 3. Protect items until relocation is complete.
 - 4. Clean and repair items to be relocated, and provide new materials, fittings, and appurtenances required to complete the relocations as required to restore them to good operating order.
- C. Perform the relocation work in accordance with applicable Sections of these Specifications, utilizing skilled workers.

3.5 SCHEDULE OF WORK

- A. Reference Division 1 for Additional Scheduling Information.
- B. Contractor and all system installers for each Section of these Specifications shall realize that the present building houses a completely functioning facility that must continue in full operation 24 hours per day during the construction period. Outages of any kind cannot occur, except only when and as the Owner's Representative or Owner may direct otherwise. Under no conditions shall any work be done in the present building that

would interfere with its natural or intended use unless special permission is granted by the Owner.

- C. Work under the various specification sections must be expedited and close coordination will be required in executing this work. Various system installers shall perform their portion of the work at such times as directed so as to insure meeting scheduled dates, and to avoid delaying the work of other trades. Owner's Representative will verify scheduled times of work in the various areas involved, each system installer shall cooperate in establishing these times and locations and the system installers shall process their work so as to insure proper execution and completion.
- D. Under no conditions shall any work be done in the present building that would interfere with its natural or intended use, unless special permission is granted by the Owner. This is particularly applicable where new connections are to be made to existing lines, services, or items of equipment in the present building or where existing equipment items or services in that building are to be replaced or modified in any way.
- E. Generally, modifications to, replacing of, or making new connections into existing service lines shall be accomplished only during the times directed by the Owner. New lines shall be installed and tested before connections are made into existing lines, meters, or services.
- F. All other modifications to existing piping systems and appurtenances, including necessary interconnections between old and new portions of the various systems, shall be accomplished at times scheduled so as not to interfere with the normal use of the building and the existing systems to which connection is to be made.
- G. The use of any type of fastening or hanging device which requires the use of shots or explosives of any nature shall not be used. Explosives shall also not be used for any excavation inside an existing building.
- H. Where required by conditions at the site, Contractor shall perform portions of work at night or at other such times as may be required to insure completion of work on schedule. No additional compensation to the Contractor will be paid for such work or required utilities.
- I. Contractor shall be available, as deemed necessary for job progress by the Owner, for weekly progress and coordination meetings with the Architect, Engineer, and other Owner's Representatives, when required. These meetings shall be used to monitor progress of submittals, receipt of materials, construction progress, cooperation of trades, field coordination by the Contractor, and to resolve unforeseen conditions in an expeditious manner. Failure to attend meetings, to respond in a timely manner to requests for information, or to progress at an acceptable pace to maintain the

construction schedule shall constitute a delay by the Contractor and may be cause for assessment of fees to the Contractor as outlined in Division 1.

- J. Provide all temporary connections as necessary to facilitate the phasing of construction, even where not specifically shown. Where temporary work is required it may be required that the Contractor produce a Shop Drawing or field sketch to illustrate the intended methods which shall be submitted for approval by the Architect.

3.6 SALVAGE, DEMOLITION, AND RELOCATION

- A. It shall be the responsibility of the Contractor to remove and store those items of existing equipment as indicated on the Drawings to be removed. All items of equipment or fixtures removed shall be protected from damage insofar as is practical.
- B. Mechanical items to be removed, salvaged, or relocated shall be removed by the respective trade who would normally be responsible to install new work similar to that to be removed. This shall include whatever selective demolition is necessary to avoid damaging other work of other trades. Each trade shall be responsible for their respective demolition. However, all trades shall keep informed as to the project schedule as it relates to the Demolition Scope of Work.
- C. These items shall be stored on site for a minimum of two (2) weeks unless indicated otherwise by the Owner's representative to allow for inspection by the Owner. Deliver, all items tagged to be retained by the Owner to a designated storage location on site or to the Owner's designated Service Center or Warehouse. All items not retained by the Owner shall be removed from the site by the Contractor at no additional cost to the Owner.
- D. The attendant piping, ductwork, hangers, foundations, etc., of those items of existing equipment to be removed, shall also be removed in their entirety. No piping, hangers, etc., shall be abandoned in place. Where branch lines are removed, the branch shall be capped as close to the main as possible.
- E. Relocations:
 - 1. Repair and restore to good functional condition materials and items scheduled for relocation and/or reuse and which are damaged during dismantling or reassembly operations.
 - 2. New materials and items of like design and quality may be substituted for materials and items indicated to be relocated, in lieu of relocation, upon approval of shop drawings, product data and samples.
 - 3. Remove carefully, in reverse to original assembly or placement, items which are to be relocated.
 - 4. Protect items until relocation is complete.

5. Clean and repair and provide new materials, fittings, and appurtenances required to complete the relocation and to restore to good operative order.
6. Perform the relocation work in accordance with pertinent sections of the specifications, utilizing skilled workers.
7. Refer to Drawings for specific requirements of temporary services and relocated equipment and fixtures.

3.7 CLEAN UP

- A. Remove all debris, rubbish, and materials resulting from cutting, demolition, or patching operations from the work area on a daily basis.
- B. Where such work generates dust and debris take all precautions necessary to prevent dust and debris from accumulating in or on other mechanical and electrical equipment. This may require adding temporary filter media over ventilation air openings of certain types of equipment.
- C. At the conclusion of this work clean all building materials, mechanical equipment and electrical equipment so that all items are dust free and operating properly. Where dust causes damage to equipment the Contractor shall make repairs to this equipment at no cost to the Owner.
- D. Transport all demolished materials and equipment indicated above in approved containers and legally dispose of all debris off site in a manner approved by the Architect and Owner.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Conditions of the Contract including the General Conditions, Supplementary Conditions, and Division One, shall apply to work of this Division, whether attached or not.
- B. The requirements specified in this Section shall be applicable to work specified in other Sections within this Division.

1.2 SCOPE OF WORK

- A. All Division 23 sections of these specifications shall include all labor and material to complete the entire mechanical systems as specified and shown on the Drawings.
- B. All work shown and specified shall be completely installed and connected by mechanics properly qualified to perform the work required. All work shall be left in a satisfactory operating condition as determined by the Owner and Owner's Representative.
- C. Provide all services and perform all operations required in connection with, or properly incidental to, the construction of complete and fully operating systems with all accessories as herein specified and shown on the Drawings.
- D. Refer to "Conditions of Work" in Division 1.

1.3 GENERAL

- A. The accompanying Drawings show diagrammatically the sizes and location of the various equipment items and the sizes of the major interconnecting piping and ductwork, without showing exact details as to elevations, offsets, control lines, and other installation details. The Contractor shall carefully lay out his work to conform to the site conditions, to avoid obstructions and provide proper grading of lines. Exact locations of outlets, apparatus, and connections thereto shall be determined by reference to the Drawings, reviewed Shop Drawings, including equipment drawings, and rough-in drawings, by measurements at the building, and in cooperation with work specified in other sections of these specifications. Minor relocations necessitated by the conditions at the site or directed by the Architect shall be made without any additional cost to the Owner.

- B. These specifications and the accompanying Drawings are intended to describe and illustrate systems which will not interfere with the structures, which will fit into available spaces, and which will insure complete and satisfactorily operating installations. Contractor shall coordinate the proper fitting of all material and apparatus into the building and shall prepare larger scale installation drawings for all critical areas, areas with limited working clearances, and areas of significant congestion requiring a higher level of coordination illustrating the installation of work specified in Division 23 in relation to all other portions of work specified in other Sections of these Specifications. Interferences with other portions of work, or the building structure, shall be corrected before any work proceeds. Should changes become necessary on account of the failure of the Contractor to comply with these stipulations, Contractor shall make all necessary changes at no expense to the Owner.
- C. All work shall be run parallel or perpendicular to the lines of the building unless otherwise noted on the Drawings.
- D. It is the intent of the Contract Documents to provide an installation complete and operational in every respect. In the event that additional details or special construction may be required for work indicated or specified in this section, or work specified in other sections, it shall be the responsibility of the Contractor to provide same as well as to provide material and equipment usually furnished with such systems and required to complete the installation.
- E. Contractor sets forth that all personnel have the necessary technical training and ability; and that all work specified in this Division will be installed to the best standard of each trade, and will be complete and in good working order. If any of the requirements of the Drawings and specifications are impossible to perform, or if the installation when made in accordance with such requirements will not perform satisfactorily, report same to the Architect promptly after discovery of the discrepancy.
- F. No extra compensation will be allowed for extra work or changes caused by failure to comply with the above requirements.

1.4 EXAMINATION OF THE SITE

- A. Contractor shall visit the site, verify all items indicated on the Drawings or specified, and familiarize himself with the work conditions, hazards, grades, actual formations, soil conditions, points of connection, utility locations, and local requirements.
- B. Contractor shall take these conditions into consideration, and the lack of specific information on the Drawings shall not relieve the Contractor of any responsibility.
- C. All site visits shall be coordinated and scheduled with the Owner.

1.5 CUTTING AND PATCHING

- A. Excessive cutting of the building structure, walls, floors, ceilings, roof, etc., will not be permitted. No structural member shall be notched or cut unless specifically shown on the Drawings, or unless such cutting is authorized by the Architect.
- B. Provide for all holes or openings of proper size and shape as may be necessary for the proper installation of work specified in Division 23, consulting with the Engineer regarding proper locations and sizes.
- C. Where deemed necessary, and after consulting with the Architect, perform all cutting and patching required for the installation of piping, ductwork, etc. This shall include the cutting of concrete floors, concrete and tile floors, walls, ceilings, roofs, etc. It shall also include patching them as required to restore work to match existing finishes, following installation, testing, backfilling, insulation, etc.
- D. Holes through concrete shall be drilled with "Mole", "Core-It", or other diamond point hole saw.

1.6 CODE REQUIREMENTS

- A. Contractor is required to comply with the requirements of all National, State, and local codes and utility companies having jurisdiction. In no case does this relieve the Contractor of the responsibility of complying with the requirements of these specifications and Drawings where specified conditions are of higher quality than the requirements of the above specified offices. Where requirements of the specifications and Drawings are below the requirements of the above offices having jurisdiction, the Contractor shall make installations in compliance with the requirements of the above offices and shall notify the Architect promptly.
- B. Contractor shall comply with the requirements and standards set forth by, but not limited to, the following:
 - 1. (NFPA) National Fire Protection Association.
 - 2. (OSHA) Occupational Safety and Health Administration.
 - 3. (NEC) National Electric Code.
 - 4. (IECC) International Energy Conservation Code.
 - 5. Local Plumbing Code.
 - 6. Local Building Code.
 - 7. Local Mechanical Code.
 - 8. Local Fire Code.
 - 9. Local Energy Code.

- C. Contractor shall obtain all permits, inspections, and approvals as required by all authorities having jurisdiction. Fees and costs incidental to these permits, inspections, and approvals must be assumed and paid by the Contractor.

1.7 RECORD DRAWINGS

- A. Contractor shall, during the execution of work, maintain a complete set of "Record Drawings" upon which all locations of equipment, ductwork, piping, and all deviations and changes in the work shall be neatly recorded for use in producing "As Builts" at Project Close- Out. This shall include the incorporation of all Supplemental Drawings issued during the Construction Period.
- B. All "Record Drawings" shall be reviewed monthly during the Construction Period, along with the monthly Pay Application Request.
- C. Refer to Section 01 70 00, Execution and Close-Out Requirements.

1.8 RECORDS AND INSTRUCTIONS FOR OWNER

- A. Accumulate during the job's progress the following sets, in triplicate, in accordance with the provisions of Section 01 70 00, Execution and Close-Out Requirements:
 - 1. Warranties and guarantees and manufacturer's directions on equipment and material covered by the Contractor.
 - 2. Equipment and fixture brochures, wiring diagrams, and control diagrams.
 - 3. Copies of reviewed Shop Drawings, and material and equipment submittals. Copies of rejected submittals and Shop Drawings are not to be provided.
 - 4. Operating instructions for heating and cooling and other mechanical systems. Operating instructions shall include recommended maintenance and seasonal change-over procedures.
 - 5. Other data and drawings required during construction.
 - 6. Repair parts lists of all major items and equipment including name, address, and telephone number of local supplier or agent.
 - 7. Valve tag charts and diagrams specified elsewhere herein.
 - 8. "As-Built" Record Drawings shall be provided in electronic format on a CD (provide two (2) copies) in a PDF or DWG format as determined by the Owner.
 - 9. Provide copies of all City Inspection Certificates of Approval.
 - 10. Provide Contractor's Certification Statement that all equipment furnished and all work performed is in compliance with all applicable codes referenced in these specifications, or those which are currently in effect.
- B. Provide not less than four (4) hours of operating instructions, during the adjustment and testing period, to the Owner's operating personnel in order to familiarize them with the proper care and operation of all equipment. Provide additional training as designated in specification section 23 08 00, Commissioning.

- C. All of the above data should be submitted to the Architect for approval at such time as the Contractor asks for his last payment request, just prior to his final payment request. In no case will any portion of retainage be released until these documents are submitted and accepted.
- D. Refer to related portions of the Owner's General Provisions for Project Close-Out requirements, Operation and Maintenance Data, Warranties, and other related certificates.

1.9 SHOP DRAWINGS AND SUBMITTALS

- A. Contractor shall submit to the Architect shop drawings, product submittals, and catalog data on all ductwork, equipment, and materials designated on the Drawings and specified herein. A minimum of eight (8) copies of each shall be submitted. Additional copies will be required when indicated by the Architect and as required for project coordination.
- B. Each submittal will be reviewed for compliance with general requirements of design and arrangement only; it is not a contract document and acknowledgement of compliance does not relieve the Contractor from responsibilities for performance of the work in compliance with all provisions and requirements of the Contract Documents. Job measurements and the coordination of all dimensions for proper fit of all parts of the work and performance of all equipment supplied to meet specification requirements are, and remain, specific responsibilities of the Contractor.
- C. Shop Drawings shall be furnished by the Contractor for the work involved after receiving approval on the make and type of material and in sufficient time so that no delay or changes will be caused. This is done in order to facilitate progress on the job, and failure on the part of the Contractor to comply shall render him liable to stand the expense of any and all delays, changes in construction, etc., occasioned by his failure to provide the necessary detailed drawings. Also, if the Contractor fails to comply with this provision, the Architect reserves the right to go directly to the manufacturer he selects and secure any details he might deem necessary; and, should there be any charges in connection with this, they shall be borne by the Contractor.
- D. Shop Drawings submitted shall not consist of manufacturers' catalogues or tear sheets therefrom that contain no indication of the exact item offered. Rather, the submission on individual items shall designate the exact item offered and accessories as specified.
- E. Shop Drawings are not intended to cover detailed quantitative lists of heating specialties, valves, air distribution devices, fixtures, and similar items, as the Drawings and specifications illustrate those items; and it is the Contractor's responsibility to procure the proper quantities required to comply with the established requirements.

- F. Shop Drawings prepared to illustrate how equipment, piping, ducts, etc., can be fitted into available spaces will be examined under the assumption that the Contractor has verified the conditions shown. Review by the Architect shall not relieve the Contractor of responsibility in the event the material cannot be installed as shown on those Shop Drawings.
- G. Various material submissions of such items as air devices, plumbing fixtures, drains, and other related items or accessories shall be assembled in brochures or in other suitable package form and shall not be submitted in a multiplicity of loose sheets. Cover sheets for each item submitted shall have sufficient bare space to allow for shop drawing review stamps.
- H. Contractor shall process his submitted data to insure that it conforms to the requirements of the Drawings and specifications, and there are no omissions and/or duplications.
- I. Shop Drawings and Submittals shall be accompanied by certification from the Contractor, and firm preparing such, that Shop Drawings have been checked for, and are in compliance with, the Contract Documents.
- J. All Submittals and Shop Drawings shall have been submitted for review by the Architect and Engineer within 90 days after Contract Award Date.

1.10 PENETRATIONS THROUGH FIRE-RATED ASSEMBLIES

- A. Seal voids around ducts and pipes penetrating fire-rated assemblies and partitions using fire-stopping materials and methods in accordance with Industry Standards and certified compliant sealant materials.

1.11 DRAWINGS

- A. Drawings show diagrammatically the locations of the various pipes, ductwork, fixtures, and equipment, and the method of connecting and controlling them. It is not intended to show every connection in detail and all fittings required for a complete system. The systems shall include, but are not limited to, the items shown on the drawings. Exact locations of these items shall be determined by reference to the general plans and measurements at the building, and in full cooperation with work specified in other Divisions of these specifications; and, in all cases, shall be subject to the approval of the Engineer. The Engineer reserves the right to make any reasonable change in the location of any of this work without additional cost to the Owner.
- B. Should any changes be deemed necessary in items shown on the Contract Drawings, the shop drawings, descriptions, and the reason for the proposed changes shall be submitted to the Engineer for approval.

- C. Exceptions and inconsistencies in plans and specifications shall be brought to the Architect's attention prior to bids being submitted; otherwise, the Contractor shall be responsible for the cost of any and all changes and additions that may be necessary to accommodate the installation of any particular apparatus.
- D. Lay out all work maintaining all lines, grades, and dimensions according to these Drawings with due consideration for the work of others. Verify all dimensions at the site prior to any fabrication or installation. Should any conflict develop or installation be found impractical, the Engineer shall be notified before any installation or fabrication, and the existing conditions shall be investigated and proper changes effected without any additional cost.
- E. Titles of Sections and Paragraphs in these specifications are introduced merely for convenience and are not to be construed as a correct or complete segregation or tabulation of the various units of materials and work. The Engineer does not assume any responsibility, either direct or implied, for omissions or duplications by the Contractor due to real or alleged error in the arrangement of matter in the Contract Documents.

1.12 CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

- A. Equipment supplied as portions of work specified under other Divisions of these specifications shall be furnished with proper roughing-in diagrams and shall be installed as a part of Division 23.
- B. Furnish materials and labor required for the connection of this equipment.
- C. Contractor shall ascertain that all equipment so specified is included as part of this work.

1.13 COOPERATION

- A. Coordinate all work indicated in Division 23 with work specified in other Divisions to assure proper and adequate interface with other portions of the work.
- B. Maintain contact and be familiar with the progress of the general construction and the timely installation of sleeves and inserts, etc., before concrete is placed. Install the required systems in their several stages, at the proper time to expedite the work and avoid unnecessary delays in the progress of other portions of the work.
- C. Should any questions arise between work specified in Division 23 with respect to other portions of work specified in other Divisions of the Specifications, reference shall be made to the Engineer for instructions.

1.14 MATERIALS AND EQUIPMENT

- A. All materials and equipment purchased shall be new. No used or reconditioned equipment will be allowed.
- B. Substitutions: Products of same functions, performance and design will only be considered if in full accordance with the requirements of the Owner's General Provisions. The products of other manufacturers will be acceptable; only if, in the opinion of the Engineer, the substitute material is of a quality as good or better than the material specified, and will serve with equal efficiency, maintainability, and dependability, the purpose for which the items specified were intended.
- C. Listed Manufacturers:
 - 1. Manufacturers listed in a product or system specification are those manufacturers considered capable of manufacturing products conforming to the specification requirements, and are listed therein to establish a standard.
 - 2. The "listing" of a manufacturer does not imply "acceptance" or "approval" of any standard product of that manufacturer.
 - 3. Products offered by listed manufacturers shall be equal to, or superior in all respects to, that specified by named products; and shall meet or exceed specification requirements.
 - 4. The description of specific qualities takes precedence over the reference standards and the description of qualities and reference standards together take precedence over the named product of listed manufacturers.
- D. Product Options:
 - 1. Products specified only by Reference Standards or by Description only means that any product meeting those standards or descriptions, by any manufacturer, will be considered.
 - 2. Products specified by naming several products or manufacturers means that only the manufacturers named will be considered.
 - 3. Products specified by naming only one product and manufacturer means that no option exists unless a substitution is accepted. Submit a request for substitution for any product or manufacturer not specifically named.
 - 4. Products specified by Description, Reference Standard, and naming several products or manufacturers means that any product and manufacturer named meeting those descriptions and standards will be considered. Submit a request for substitution for any product or manufacturer not specifically named.
- E. Limitations or Substitutions:
 - 1. During Bidding Period, Instructions to Bidders, in the Owner's General Provisions, will govern times for submitting requests for substitutions under requirements specified in this Section.
 - 2. No later than ten (10) days prior to the bid date, Contractor shall notify the Architect in writing of any desired substitutions of products in place of those

- specified. These requests will be considered; and, if a favorable response is determined, this will be documented in the form of an Addenda.
3. Substitutions will not be considered when indicated or implied on Shop Drawings or product data submittals without separate formal request, when requested directly by subcontractor or supplier, or when acceptance will require substantial revision of Contract Documents.
 4. Substitute products shall not be ordered or installed without written acceptance.
 5. Only one request for substitution for each product will be considered. If substitution is not accepted, Contractor shall provide specified product.
 6. Engineer will determine acceptability of any and all substitutions.
- F. It is fully the Contractor's responsibility to assemble and submit sufficient technical information to fully illustrate that the material or equipment proposed for substitution is equal or superior, as the Engineer is under no obligation to perform the service for the Contractor. The proposal shall be accompanied by manufacturer's engineering data, specification sheet, and a sample, if practical or if requested or specified. In no event shall a proposal for substitution be cause for delay of work. This shall include a detailed comparison to each product specification paragraph.
- G. Should a substitution be accepted under the above provisions, and should the substitution prove defective or otherwise unsatisfactory for the intended service, within the warranty period, the Contractor shall replace the substitution with the equipment or material specified, and on which the specifications required him to base his proposal.
- H. No substitutions will be considered contingent upon pending certification and rating agency approvals. Such certifications and ratings shall be in effect at the time of bidding.

1.15 EQUIPMENT SIZES AND REQUIREMENTS

- A. Space allocations in machinery and mechanical equipment spaces are based on equipment scheduled in each case. Should the Contractor request a substitution for equipment of another make that requires more space in any critical dimension, the Contractor shall submit, together with other submittal data on the equipment, prints of drawings indicating how the equipment may be installed, indicating room for servicing and revisions in piping or ducting and any other details necessary for the Engineer to form a judgment as to the suitability of the substitute material, as to performance, suitability for the space and other variables.
- B. Duties of certain equipment items, horsepower of driving motors and electrical characteristics are scheduled for equipment items of a particular make in each case. Should requests for a substitute material be accepted which has other requirements that would involve allied equipment or other portions of work, the Contractor shall be responsible for all modifications required at no change in contract price. As examples:

1. If an accepted A/C Unit has a brake horsepower requirement above the motor horsepower scheduled, the Contractor shall be responsible for providing a larger motor and heavier drive and any change in size of the protective device, conduit run and conductors serving that motor. The latter shall be extended through an individual branch protective device and branch circuit on through the panel, feeder, feeder protective device, etc.
- C. Structural steel members are indicated to provide supports for certain specific sizes and weights of equipment. Should a substitution request involve other equipment, the spacing of the supports shall be varied to suite the equipment. Should the weight or size of a proposed substituted item of equipment require additional supporting steel members, the Contractor shall include documentation of the additional supports in the request for substitution and install them at no change in contract price if the substitution is accepted.
- D. Various large apparatus to be installed may require that the apparatus be installed prior to the installation of portions of structural, walls, or door frames. Coordinate the installation of these items to insure that no demolition of general construction is necessary for equipment installation or that the apparatus does not have to be disassembled for installation.

1.16 STORAGE AND PROTECTION OF MATERIALS

- A. Store and protect materials and equipment as specified in the Owner's General Provisions.
- B. Contractor shall provide storage space for protection and storage of his materials and assume complete responsibility for all losses due to any cause whatsoever. All storage shall be within the property lines of the building site, and as directed by the Engineer. In no case, shall storage interfere with traffic conditions in any public or project thoroughfare.
- C. All work and material shall be protected at all times. Contractor shall make good any damage caused, either directly or indirectly, by his workmen. He shall be responsible for safe handling of all mechanical equipment and shall replace, without charge, all items damaged prior to acceptance by the Owner.
- D. On site storage shall not be inside the building during construction progress, but shall be in approved trailers or as specifically approved otherwise by the Engineer. Storage inside the building shall only be allowed when so allowed by the Engineer.

1.17 FOUNDATIONS

- A. Provide equipment foundations associated with the work specified in Division 23.

- B. All top corners and edges of all foundations shall be neatly chamfered at a one inch (1") high 45 degree angle.
- C. Foundation bolts shall be placed in the forms when the concrete is poured. Allow one inch (1") below the equipment bases for alignment, leveling, and grouting with non-shrinking grout. Grouting shall be done after the equipment is leveled in place. After the grout has hardened, the foundation bolts shall be pulled up tight and the equipment shimmed, if necessary.
- D. After removal of the forms, the surface of the foundation shall be rubbed until smooth.
- E. Unless otherwise noted, foundations shall be six inches (6") high for medium pressure rated air handling units, and four inches (4") thick elsewhere for low pressure rated air handling units and other mechanical equipment, unless specifically noted otherwise on the Drawings.
- F. All concrete work shall conform to the requirements of Industry Standards using minimum 3,000 PSI strength concrete (28 Day results).
- G. Provide housekeeping pads and foundations for every item of floor or pad mounted equipment specified in Division 23 specifications. Pads shall extend a minimum of two inches (2") in each direction beyond the equipment size.

1.18 EXCAVATION AND BACKFILLING

- A. Contractor shall do all necessary excavating and backfilling for the installation of his work. Trenches for underground conduits shall be excavated to required depths with bell holes provided as necessary to insure uniform bearing. Care shall be taken not to excavate below depth, and any excavation below depth shall be refilled with sand or gravel firmly compacted. Where rock or hard objects are encountered, they shall be excavated to a grade six inches (6") below the lowermost part of the piping and refilled to grade as specified. After the piping has been installed and reviewed by Architect and local building authorities, trenches shall be backfilled to grade with approved materials, well tamped or puddled compactly in place. Where streets, sidewalks, etc., are disturbed, cut, or damaged by this work, the expense of repairing same in a manner approved by Engineer shall be a part of this contract.
- B. Contractor shall bear sole responsibility for design and execution of acceptable trenching and shoring procedures, in accordance with State of Texas Regulations. On trench excavations in excess of five feet (5') in depth, Contractor shall pay a qualified engineer to prepare detailed Drawings and specifications directing Contractor in the safe execution of trenching and shoring. It is understood that trench safety systems constitute a means and method of construction for which the Engineer and Owner are

not responsible. Accordingly, such documents when prepared, shall be separately issued by Contractor's Consultant, independent of project contract Documents.

- C. Where granular bedding backfill is used (includes gravel and sand) provide concrete cut-off collars of clay plugs where ever utility lines cross building lines to prevent water from traveling in the trench backfill and entering beneath the structure.
- D. Refer to soils testing report for recommendations on backfill material, compacting instructions and criteria for materials to be used.

1.19 WIRING

- A. Unless otherwise noted, all wiring for motors, starters, and equipment is specified in Division 26.
- B. Wiring of temperature controls shall be performed in accordance with the requirements of Division 26 but shall be performed as outlined in other sections of these specifications.
- C. All power for control circuits required for the Temperature Control System shall be provided and installed where indicated on the Division 26 Drawings, but shall otherwise be provided as indicated in other sections of these specifications.
- D. Each supplier of equipment requiring control shall have wiring diagrams furnished with submittals. This shall be used to determine conduit layouts required to complete the electrical portions of the instrumentation and control systems.
- E. All motors furnished as a portion of work specified in Division 23 shall be wired as specified in Division 26.
- F. Except where combination starter-disconnects are specified elsewhere herein or in Division 16, all motors shall be provided with safety disconnect switches in accordance with the National Electrical Code as specified in Division 26.
- G. Furnish all necessary wiring diagrams for equipment specified in Division 23, as a part of equipment submittals, for installation under other sections of these specifications.

1.20 EQUIPMENT STANDARDS

- A. All basic materials and equipment shall be standard catalog products of a reputable manufacturer and shall essentially duplicate equipment which has been in satisfactory service for at least one (1) year.
- B. First of a kind new technology devices will not be considered.
- C. Accessory equipment that is required to make a complete and functioning system that is not of the same manufacturer furnishing the basic materials or equipment shall carry the

guarantee of the basic material or equipment manufacturer and repair and replacement parts shall be available through normal trade channels locally.

1.21 CLEAN UP

- A. Contractor shall be responsible for cleaning up after and during all work performed under this Division of the Specifications.
- B. Contractor shall, on a daily basis, remove construction trash and debris accumulation to minimize the entrance of dust, dirt, and debris in piping, ductwork, and mechanical equipment.
- C. At the completion of construction, just prior to Substantial Completion and sustained operation of equipment, thoroughly clean the inside of piping, ductwork, and equipment.
- D. Refer to Owner's General Provisions.

1.22 FINAL CONSTRUCTION REVIEW

- A. Schedule: Upon completion of the work specified in Division 23, there shall be a final construction review of the completed mechanical systems installations. Prior to this walk-thru, all work specified in this Division shall have been completed, tested, adjusted, and balanced in its final operating condition and the preliminary test report shall have been submitted to and approved by the Engineer.
- B. Personnel: A qualified person representing the Contractor must be present at this final construction review to demonstrate the system and prove the performance of the equipment.
- C. Building mechanical systems shall have been in operation for a minimum of 15 days and Test and Balance work shall be substantially complete prior to this review.
- D. Exceptions to the aforementioned requirements will be considered on a case-by-case basis dependent on the size and type of project, as well as construction schedule limitations.

1.23 CERTIFICATIONS

- A. Before receiving final payment, the Contractor shall certify that all equipment furnished and all work done is in compliance with all applicable codes mentioned in these Specifications.
- B. Provide copies of all applicable approved notices and inspection certifications from the various inspections conducted by the Local Code Enforcement Authorities.

1.24 GUARANTEE

- A. The guarantee provision of this specification requires prompt replacement of all defective workmanship and materials occurring within one year of final job acceptance, Substantial Completion, or as defined by Extended Warranty Contracts. This includes all work required to remove and replace the defective item and to make all necessary adjustments to restore the entire installation to its original specified operating condition and finish at the time of acceptance.
- B. The Contractor shall also guarantee that the performance of all equipment furnished and installed under this Division of the Specifications shall be at least equal to the performance as called for in the specifications and as stated in the equipment submittals. Should there be indication that the equipment and installation is not producing the intended conditions, the Contractor shall make further tests as the Owner's Representative may direct to demonstrate that the equipment installed meets the specifications and is delivering the capacity specified or called for on the Drawings.
- C. If there is any indication that the equipment does not meet the specified quantities, the Contractor shall, at his expense, institute a program to demonstrate the adequacy of the installation. This program shall include all necessary testing and testing equipment. Should the Contractor not have the equipment or technical skill to perform the tests, it shall be his responsibility to employ recognized experts to perform the tests and shall provide certified laboratory tests, certified factory reports and work sheets, or other certified data to support results of any tests required.

END OF SECTION

SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with Division 23 Sections, as applicable. Refer to other Divisions for coordination of work with other trades, as required.

1.2 SYSTEM DESCRIPTION

- A. Provide motors for all mechanical equipment furnished under Division 23, as indicated herein and as illustrated on the Contract Drawings.
- B. All motors shall be of the same manufacture for like pieces of equipment; i.e., air handling equipment shall have motors of the same manufacturer.
- C. The following equipment with 3 phase 1 horsepower motors or larger shall be provided with NEMA Premium efficiency motors as specified herein:
 - 1. Indoor Direct Expansion Fan coil units.
 - 2. Larger Split Direct Expansion remote air cooled condensing units.
- D. Three phase, horizontal, NEMA frame induction motors served by AC Adjustable Frequency Motor Controllers shall be designed to meet the intent of NEMA MG1, Part 31, Section 31.40.4.2 regarding voltage spikes without exception.

1.3 SUBMITTALS

- A. Submit shop drawings and product data under provisions of specification section 23 05 00.
- B. Indicate on submittal the motors proposed for each system of equipment to be installed. This shall be in tabular form in one location for each type of equipment submitted. The lack of this information will be grounds for rejection of equipment submittals.
- C. Product Data shall be furnished which shall include:
 - 1. Motor Manufacturer.
 - 2. Motor Type; Open Drip Proof, Totally Enclosed (Fan Cooled or Air Over).
 - 3. Model of Manufacturer.
 - 4. Motor Horsepower.
 - 5. Motor RPM.

6. NEMA Motor Efficiency at 25%, 50%, 75%, and 100% of Full Load Rating for motors served by variable frequency drives; 100% only for constant speed motors 1 HP and larger.
 7. Power Factor at 25%, 50%, 75%, and 100% of Full Load Rating for motors served by variable frequency drives; 100% only for constant speed motors 1 HP and larger.
 8. Service Factor.
- D. Certification: Provide manufacturer's literature indicating NEMA premium motor efficiency as tested in accordance with IEEE Standard 112, Test Method B. Provide documentation to verify motors served by variable frequency drives meet NEMA MG1, Part 30 for 6-step drives and Part 31 for PWM drives.
- E. Provide closeout documents as required in Division 1.

1.4 QUALITY ASSURANCE

- A. Comply with all regulatory requirements in the following order of precedence:
1. Codes, laws, ordinances, rules, regulations or orders of any public authority having jurisdiction over installation, inspection, and testing, including local codes.
 2. Provisions specified in this Section of Specifications.
 3. Applicable provisions of standards of National Electric Code (NEC).
- B. Manufacturer shall have been manufacturing the motors as described herein for a minimum of ten (10) years.

PART 2 - PRODUCTS

2.1 ELECTRICAL MOTORS, GENERAL

- A. All motors furnished under any of the several sections of these specifications shall be of a recognized manufacturer, be of adequate capacity for the loads involved, and conform for the electrical characteristics indicated on the Drawings and specified herein. Verify all job site voltages and power source available before submitting, ordering and installing any motor or related controls.
- B. Motors shall conform to the standards of manufacture and performance of the National Electrical Manufacturer's Association (NEMA) as shown in their latest publication.
- C. Motors shall be furnished with an open-frame, unless otherwise noted, or required by the NEC for the service conditions encountered. Motors exposed to weather shall be the totally enclosed type suitable for installation in ambient conditions for exposure to the sun, heat, and rain. Provide explosion proof motors where indicated and as required for the hazard in which to be installed.

- D. Unless otherwise noted, fractional motors rated at 1/2 horsepower and less shall be single phase, the motors rated at larger than 1/2 horsepower shall be three phase. Single phase motors shall be arranged for across-the-line starting.
- E. Single phase motors shall be capacitor start, induction run type, and shall be furnished with motor controller with pilot light where scheduled or indicated. Refer to Section 23 05 14.
- F. All motors shall be of the same manufacturer on similar equipment furnished by the same manufacturer, unless they are an integral part of the piece of equipment to which they are attached, such as a chiller. Air Handling Units shall have motors of the same manufacture.
- G. Three phase motors shall generally have the following characteristics:
 - 1. All copper windings.
 - 2. Type K, NEMA Design "B".
 - 3. Normal Starting Torque.
 - 4. Class B insulation.
 - 5. Continuous Duty Rated.
 - 6. 40 Deg.C. ambient rated.
 - 7. Minimum 1.15 Service factor on motors 1 horsepower and larger; 1.25 service factor on motors 3/4 horsepower and smaller.
 - 8. 1800 RPM unless scheduled otherwise.
 - 9. Oversize steel conduit boxes.
 - 10. Greasable bearings.
 - 11. Stainless steel or aluminum motor nameplates for standard motor information.
 - 12. Cold rolled steel 1045 shaft.
 - 13. Steel frame and splash cover.
- H. Where other sections of specifications do not call for premium efficiency motors this section shall apply to motor requirements. Where premium efficiency motors are required in the other Sections of these Specifications refer to Article 2.2 herein.
- I. Motor manufacturers shall be Reliance, Baldor, General Electric, A.O. Smith or U.S. Motors. Other manufacturers will not be considered.

2.2 PREMIUM EFFICIENCY ELECTRICAL MOTORS

- A. All premium efficiency electrical motors furnished under any of the several sections of these specifications shall be of a recognized manufacturer, be of adequate capacity for the loads involved, and wound for the electrical characteristics indicated on the Drawings and specified herein. Verify all job site voltages and power source available before submitting, ordering and installing any motor or related controls.

- B. Motors shall conform to the standards of manufacture and performance of the National Electrical Manufacturer's Association (NEMA) as shown in their latest publication.
- C. Motors shall be furnished with an open-frame, unless otherwise noted, or required by the NEC for the service conditions encountered. Motors exposed to weather shall be the totally enclosed type suitable for installation in ambient conditions for exposure to the sun, heat, and rain. Provide explosion proof motors where indicated and as required for the hazard in which to be installed.
- D. All NEMA Premium efficiency motors shall be three phase.
- E. Except as otherwise specified NEMA Premium efficiency motors shall be drip-proof, squirrel cage, premium efficiency type as manufactured by A. O. Smith (E Plus III), Baldor (Super E), Reliance (Duty Master XE), General Electric (Energy Saver), or U.S. Motors Premium Efficiency NEMA Design B, induction type rated for constant duty with 40 Deg.C. ambient temperature rise. The motors shall have the following characteristics:
 - 1. 1800 RPM unless scheduled otherwise.
 - 2. 1.15 Service Factor.
 - 3. Rigid base.
 - 4. Serialized and certified.
 - 5. Stainless steel nameplate.
 - 6. Class B insulated.
 - 7. 60 Hertz.
 - 8. High power factor.
 - 9. Ball Bearings.
- F. Totally enclosed motors and motors served by variable frequency drives shall be Class F insulated.
- G. Minimum Nominal motor efficiencies at 1800 RPM, 208V, 4 pole, full-load, per IEEE Standard 112, test method B, as defined by NEMA MG1-12.53, a and b, shall be as follows, along with minimum power factor:

MOTOR HP	NOMINAL EFFICIENCY		POWER FACTOR	
	TEFC	ODP	TEFC	ODP
1	85.5	85.5	84.0	84.0
1.5	86.5	86.5	85.7	85.7
2	86.5	86.5	85.7	85.7
3	89.5	89.5	85.5	85.5

- H. Furnish submittal data on all NEMA Premium efficiency motors furnished to include motor efficiencies as rated in accordance with IEEE Standard 112, Test Method B.
- I. All motors shall be of the same manufacturer on similar equipment furnished by the same manufacturer. Air Handling Units shall have motors of the same manufacture' and pumps shall have motors of the same manufacture.
- J. Each variable torque motor served by a variable frequency drive shall be capable of operating over a 10:1 speed range.
- K. Each premium efficiency motor shall be warranted for a minimum of three (3) years.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Motors shall typically be furnished by the manufacturer of the equipment which the motor will serve.
- B. Motors shall be factory installed in the equipment and be mounted on equipment bases, wired to a terminal box, connected to the mechanical device to be rotated, and factory run tested.
- C. When project schedules will not allow the above due to excessive lead time requirements, the Contractor shall do one of the following all at no additional cost:
 - 1. Locally procure the specified motors, while meeting all of the above requirements, and field install the motors on the equipment in accordance with the manufacturer's installation instructions.
 - 2. Accept factory installed standard efficiency motors and replace with high efficiency motors as noted above.
- D. Motors disconnects will be furnished and installed under Division 26, unless integral with, or specified to be a part of, the equipment as indicated elsewhere in other sections

of these Specifications. The wiring to the motor and installation of the motor controller, if not specified to be integral with the equipment, as furnished under other sections of these specifications, shall also be installed under Division 26.

- E. Interlock and control voltage wiring shall be installed as outlined in other Sections of these Specifications.

END OF SECTION

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections, as applicable. Refer to other Divisions for coordination of work with other portions of work.

1.2 SYSTEM DESCRIPTION

- A. A complete system of vibration isolation for all mechanical equipment subject to the transmission of noise and vibration to the building.

1.3 QUALITY ASSURANCE

- A. All equipment and materials shall be new and of the best quality and have been manufactured by a firm with a minimum of five (5) years of experience in this field.
- B. All equipment and materials shall be installed in a workmanlike manner by experienced mechanics and as recommended by the equipment and vibration isolation manufacturers.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions for all vibration isolation equipment.
- B. Shop Drawings: Submit in accordance with Section 23 05 00.

1.5 PRODUCT HANDLING

- A. Cover and protect material in transit and at site. Material not properly protected and stored and which is damaged or defaced during construction shall be rejected.
- B. Storage and protection of materials shall be in accordance with Section 23 05 00.
- C. Install materials and equipment at the proper time to keep pace with the general construction and the work of other trades involved so as not to delay the project completion schedule.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Objectionable vibration or noise created in any part of the building by the operation of any equipment furnished and/or installed under Division 23 will not be permissible.
- B. Contractor shall take all precautions against the same by isolating the various items of equipment, pipes, and ducts from the building structure and by such other means as may be necessary to eliminate the transmission of excessive vibration and objectionable noise produced by any equipment installed thereby.
- C. Design all foundations, supports, etc., for equipment, piping and ductwork with this end in view.
- D. Contractor shall supervise and instruct the construction of all foundations and supports, in order that they may be constructed in such manner as to prevent the transmission of noise and vibration.

2.2 APPLICATIONS

- A. Isolating material shall be selected in each case in accordance with the manufacturer's recommendations and the latter shall be prepared to demonstrate, upon request of the Architect, the isolation effectiveness of the material which has been installed upon his recommendation.
- B. Isolators shall be so selected that when all the items in each of the mechanical rooms are in simultaneous operation, the vibration transmission to the building at the lowest disturbing frequency shall be limited to a maximum of 10% for a mechanical equipment room floor that is on the ground and 5% for all other building surfaces, including those in fan rooms, from all the equipment when the various items are in harmony.
- C. Isolators for supporting ducted Fan Coil Units suspended from the construction above on rod hangers, not internally isolated, shall be of the open spring type with housings and noise washers, lock washers, nuts, etc. Isolators shall be similar to Amber Booth type BSW-1 or KDXW-1 with a minimum 1 inch deflection. For fan coil units less than 1000 CFM in capacity they may be isolated with rubber-in-shear isolating grommets in lieu of spring isolators.
- D. Outdoor pad mounted air cooled condensing units shall be installed on concrete housekeeping pads which shall also be mounted on ribbed neoprene pads equal to Amber Booth Ampad Type NR or NRC, Style B isolators.

2.3 MANUFACTURERS

- A. Isolating materials used shall be:
 - 1. Amber-Booth (The VMC Group) or approved equals by,
 - 2. Korfund Dynamics (The VMC Group) or,
 - 3. Vibro-Acoustics or,
 - 4. Mason Industries or,
 - 5. Kinetics Noise Control, Inc.

PART 3 - EXECUTION

3.1 PERFORMANCE OF ISOLATORS

- A. Comply with recommendations set forth by the American Society of Heating, Refrigerating and Air Conditioning Engineers for the selection and application of vibration isolation materials and units.
- B. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units.
- C. Place isolators where indicated and where specified herein. Coordinate all isolator selections with approved equipment and other pertinent shop drawings of exact equipment to be isolated. Verify to ensure accuracy of load points and take into account any accessory devices adding to equipment loads to be supported by isolators.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC DUCTWORK, EQUIPMENT AND PIPING

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with the Owner's General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other portions of the work.

1.2 SYSTEM DESCRIPTION

- A. Provide a complete system of Piping and Identification as specified herein for each of the systems as described herein.
- B. Provide a complete system of valve identification by the use of tags as described herein.
- C. Provide a complete system of equipment identification tags as described herein.

1.3 QUALITY ASSURANCE

- A. The installation of all mechanical system identification devices shall be performed under this Section of the Specifications using materials which are the product of reputable manufacturers. The application of the materials shall be in strict accordance with the published standards of the manufacturer of the materials, using any special materials as required by these specifications and by those published standards.
- B. Manufactured Piping Identification markers, equipment name plates and valve tags shall be a product of Seton Name Plate Corporation, EMED Company, Inc., or Craftmark Identification to meet all ANSI Standards pertaining thereto.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions in accordance with Section 23 05 00.
- B. Shop Drawings:
 - 1. Submit a list of all piping and systems to be identified, color of background to be used, legend or wording to be displayed for each system, and the intended location of all markers to be displayed.
 - 2. Submit a list of equipment to receive identification tags, cut sheets and proof copies of tags which indicate location of tag and wording to be engraved thereon.

3. Submit a list of valves with location, indicate type of service, type of tag, tag number and proposed valve tag chart as specified herein.

1.5 PRODUCT HANDLING

- A. Cover and protect material in transit and at site. Material not properly protected and stored and which is damaged or defaced during construction shall and will be rejected.
- B. Storage and protection of materials shall be in accordance with Section 23 05 00.

PART 2 - PRODUCTS

2.1 PIPING IDENTIFICATION SYSTEM

- A. Furnish piping identification markers for all insulated and uninsulated piping systems in sizes and colors in accordance with ANSI Standard A13.1. Markers shall be as manufactured by Seton Name Plate Corporation similar to their vinyl plastic "Setmark" pipe markers with flow arrows. For systems with overall outside diameters under 6" use the snap-around markers. For systems with overall diameters 6" and over use strap-around markers attached with nylon ties.
- B. Markers shall be provided as a minimum for the following systems:
 1. Condensate Drains, Auxiliary Drains and basic system Drains (Green Background-White Letters), for all insulated drains not contained in one space or on the roof; i.e., an A/C condensate drain in a fan room shall not require identification, whereas, as drain extending to another space would.
 2. Refrigerant Piping (Green Background-White Letters); label as to the service type of the piping such as "Suction Line", "Refrigerant Liquid" or other designation.

2.2 EQUIPMENT IDENTIFICATION

- A. Contractor shall provide custom identification plates similar and equal to Seton Custom Engraved Phenolic Plastic Equipment Nameplates for indoor applications and Custom Aluminum Engraved Equipment Nameplates for outdoor applications, as further indicated herein. Only name plates equal to those specified will be considered.
- B. Indoor Name plates shall be a minimum of 1/16" thick flexible multi-layered phenolic plastic and be 1" X 3" in size with beveled edges. The surface shall be black satin with a white core for lettering. Other color combinations may be used for specific systems, where warranted and as indicated herein. Each nameplate shall have three (3) lines of bolded engraved text sized to fit the maximum space available (approximately 3/16" to 1/4" high text), Each plate shall be drilled with two mounting holes sized for 3/8" No. 3 round head nickel plated steel screws (furnish these screws with the nameplates) and be screw attached in approved locations. Lettering shall be a of 3/16" high, and lettering shall be cut through the black surface to the white core and be "Gothic Normal".

- C. Outdoor equipment nameplates shall be custom engraved aluminum (0.020" thickness) equipment nameplates, be 1" high by 3" wide, have a blue weather resistant paint finish over-laminated on the aluminum, have three (3) lines of bolded engraved text sized to fit the maximum space available (approximately 3/16" to 1/4" high text), include two (2) side mounting holes sized for 3/8" No. 3 round head nickel plated steel screws (furnish these screws with the nameplates) and be screw attached in approved locations.
- D. The first line of text shall state the property owner's name, such as the "Town of Fairview". The second line of text shall identify the equipment tag from the schedule, such as "AHU-1-2". The third line of text shall designate the area the equipment serves or the intended service of the equipment, such as "WORKSHOP AREA".
- E. No punched plastic tape or stick-on plates are acceptable.
- F. Provide and install identification plates on the cover of all starters or disconnects, combination starter-disconnects, and variable frequency drives, where these are not mounted directly on the equipment. Further install nameplates on each equipment item as designated herein. For disconnects and motor controllers, the mechanical system installer shall furnish those nameplates to the electrical systems installer who will be responsible to install those nameplates only. The mechanical systems installer shall install all nameplates on each piece of Mechanical Equipment to include but not necessarily limited to:
 - 1. VRV/VRF Fan Coil Units.
 - 2. Split Direct Expansion Indoor (Fan Coil) A/C Units.
 - 3. Remote Air-Cooled Condensing Units.
- G. Name plates shall have complete words describing equipment type, use and service. As an example, air handlers shall be designated "AHU-S-X MEP Shop" to designate the equipment as an air handler, number of air handler and area served. Use multiple or larger name plates as required to fulfill this requirement.

PART 3 - EXECUTION

3.1 PIPE MARKER INSTALLATION

- A. Provide flow arrows at each marker location.
- B. Markers shall be spaced not more than 30 feet on center and at each change of direction but not more than 4 feet in each direction from each elbow and tee. Markers not required on piping runouts less than four feet (4') in length and 1-1/4" or smaller in size.
- C. Identification markers shall be installed on all new piping; indoors, outdoors and in the crawl space.

- D. Install markers on exposed piping systems only after jacketing systems and finish paint coats are complete. Refer to Section 23 07 00.

3.2 IDENTIFICATION TAG INSTALLATION

- A. Secure tags level and in a conspicuous location with adhesive on equipment starters or combination starter disconnects and on the equipment where starters are not immediately adjacent to the equipment served.
- B. Additionally, secure all tags with screw fasteners after secured with adhesive.

END OF SECTION

SECTION 23 05 93

MECHANICAL SYSTEMS TESTING, ADJUSTING, AND BALANCING (TAB)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Section shall be related to the General Provisions of the contract, including General and supplementary conditions.
- B. Refer to Section 23 05 00 for general provisions.

1.2 SCOPE OF WORK

- A. The work included in this Section consists of the furnishing of all labor, instruments, tools and services required in connection with the Testing, Adjusting and Balancing (TAB) of the Heating, Ventilating and Air Conditioning (HVAC) systems as described in the mechanical specifications and shown on the mechanical Drawings, or reasonably implied therefrom, to include the overall commissioning of systems and subsystems such as verification of operation of each control device and all equipment sequences of operation.
- B. TAB of the HVAC systems will be performed by an impartial independent Technical Firm who is a member of the Associated Air Balance Council (AABC) and whose operations are limited only to the field of professional TAB work. The firm selected shall not be engaged in any contracting, manufacturing or engineering services. The TAB Contractor has been pre-selected and shall be Engineered Air Balance Company, Inc. (EAB).
- C. TAB Firm is responsible to and shall submit all reports directly to the Engineer and as requested, to the Owner.
- D. TAB services shall result in the optimum temperature, humidity, airflow, pressurization, ventilation rates, and noise levels in the conditioned spaces of the building.
- E. The following basic components of the HVAC systems shall be tested, adjusted and balanced:
 - 1. Air distribution systems.
 - 2. Air moving equipment.
 - 3. Cooling systems.
 - 4. Heating systems.

5. HVAC control systems verification to include end devices, control sequences of operation and energy management system control and monitoring point verification.

F. Document Review

1. The TAB Firm shall be responsible for reviewing the HVAC Drawings and specifications relating to the TAB services for proper arrangement and adequate provisions of devices for testing, adjusting and balancing.
2. TAB Firm shall review HVAC manufacturer's submittal data relative to suitable provisions to allow system to be balanced.
3. TAB Firm shall review submitted HVAC automatic temperature control sequences for conformity to the specifications.

- G. Two (2) .PDF file copies saved onto Compact Disks (CD's), or Flash Drives, or sent electronically, of the final report shall be submitted to the Owner, or designated representative thereof, and engineer, indicating a summary of actual operating data and any abnormal operating conditions. The report will contain all required information as described within this specification. The files shall also include copies of HVAC drawings annotated to reflect tags used for air and water components balanced.

1.3 SERVICES OF CONTRACTOR

- A. Contractor shall start up and test all materials and equipment which normally require testing. All piping, ductwork, etc., shall be tested to meet code requirements and the specification requirements, whichever is the more stringent. All equipment shall operate a sufficient length of time at the Contractor's expense to prove to the Engineer, and Owner that the equipment is free from mechanical defects, runs smoothly and quietly and performs satisfactorily to meet the requirements set forth in the Mechanical Drawings and Specifications.
- B. In order that all HVAC systems can be properly tested, adjusted and balanced, the Contractor shall operate the HVAC systems at their expense for the length of time necessary to properly verify their completion and readiness for TAB, and shall further operate and pay all costs of operation during the TAB period if not otherwise specifically addressed to be paid by the Owner. Operating expenses to be paid for by the Contractor (not TAB firm) will include, where applicable, but not necessarily be limited to, the following:
1. Personnel costs to start, operate and stop all HVAC equipment.
 2. All start-up labor and materials costs.
 3. All maintenance costs until accepted by the Owner.
 4. Utility costs will be born by the Owner.
- C. The drawings and specifications have indicated dampers and miscellaneous adjustment devices for the purpose of testing, adjusting and balancing the HVAC systems to obtain

optimum operating conditions. It will be the responsibility of the Contractor to install these devices in a manner that will leave them fully accessible and readily adjustable to include access to allow recording of all motor and fan nameplate data. The TAB firm shall be consulted if there is a questionable arrangement of a control or adjustable device. Should any such device not be readily accessible, the Contractor shall provide access as required by the TAB firm.

- D. Contractor shall provide and coordinate the services of qualified, responsible sub-contractors, suppliers, and personnel as required to correct, repair or replace any and all deficient items or conditions found before and during the TAB period.
- E. As a part of this Project Contract, the Contractor shall make any changes in the sheaves, belts, drives, motors, dampers, or the addition of dampers as required, to correctly balance the HVAC systems as required by the TAB firm at no additional cost.
- F. Provide sufficient time in Project Contract completion schedule to permit the completion of TAB services prior to Owner occupancy of the project.
- G. Contractor shall furnish, without charge to the TAB Firm, the following (Digital and Hard Copies):
 - 1. One (1) complete set of project specifications to include all mechanical sections.
 - 2. One (1) complete set of Contract Drawings.
 - 3. All pertinent change orders and all Addenda.
 - 4. Two (2) complete sets of mechanical plans with latest revisions.
 - 5. Any "As-installed" and shop drawings.
 - 6. Approved HVAC system control diagrams.
 - 7. Approved manufacturer's submittals for all HVAC equipment to be included in the TAB scope of work.
- H. Have all HVAC systems complete and in operational readiness prior to notifying the TAB Firm that the project is ready for TAB services. So certify in writing to the Engineer, and Owner that such a condition exists. Complete operational readiness prior to commencement of TAB Services shall include the following:
 - 1. Air Distribution Systems:
 - a. Verify installation for conformity to design of all supply, return and exhaust ducts.
 - b. Verify that all volume dampers, smoke dampers and fire dampers are properly located, functional and open; verify that properly located, sized, and labeled access doors are installed in ducts and in general construction (ceilings, walls, furrings, etc.).
 - 1) Contractor shall manually release the fire, smoke or fire-smoke damper which shall be witnessed by the TAB firm or local municipality

representative; to observe the full opening and closing of the dampers.
Document these witness tests in writing.

- 2) Contractor shall open or reset fusible links on these dampers, as required.
 - 3) Contractor shall furnish tags at each damper for recording the date, time and individual who last verified the operation of each damper.
- c. Verify that minimum outside air dampers provide tight closure, open fully and operate smoothly and freely.
 - d. Verify that all new supply, return and transfer air diffusers, grilles and registers are installed as indicated on the mechanical Drawings.
 - e. Verify that all air handling units, etc. and associated apparatus such as heating coils, cooling coils, filter sections, access doors, etc., have been blanked and sealed to eliminate the bypass of air around the coils, filters, etc. or leakage of air into or out of the unit.
 - f. Install the specified type and quantity of clean filters at each air handling unit and maintain these filters for the complete period that the subject system is being tested, adjusted, and balanced. Refer to Specification Section 23 30 00. New filters shall be installed just before air balance work is performed to insure clean filters are the basis of the test data provided.
 - g. Verify that all (supply and condenser) fans are operational including proper fan rotation, operates free from vibrations, belts are properly aligned, and belt tension is proper, as applicable.
 - h. Verify that all motor starter overload heater elements are of proper size and rating; nameplate amperage to be within the range of the heater element size.
 - i. Make a record of actual motor amperage and voltage, for each phase, and verify that they do not exceed nameplate ratings.
 - j. Verify specified vibration isolation accessories are correctly installed and adjusted.
 - k. Ensure that all fan drive components, motors, belts, sheaves, and fan wheels, as applicable, are all accessible to allow for servicing and verification of name plate data, sizes, and model and serial numbers, as applicable.
 - l. Provide additional air balance dampers, and replacement sheaves and belts, as applicable to successfully complete TAB work.
 - m. Flag all new air balance dampers with fluorescent, or other high visibility tape, leaving a minimum of one inch (1") wide by three inches (3") long exposed to view.

I. Automatic Controls:

1. Verify that all control components are installed in accordance with project requirements and are functional as intended by these specifications, including all

- electrical interlocks, damper sequences, air temperature resets, fire-stats, duct smoke detectors, safeties, etc.
2. Verify that all controlling instruments are calibrated and set for design operating conditions with the exception of room thermostats which shall be calibrated at the completion of TAB services in full cooperation between TAB Firm and controls system installer.
 3. Automatic temperature control and/or energy management system installer shall thoroughly check all controls, sensors operators, sequences of operation, etc. before notifying the TAB agency that the automatic temperature controls and energy management system are operational. Automatic temperature control and/or energy management system installer shall provide technical support staff (technicians and necessary hardware and software) to the TAB agency to allow for a complete check out of these systems; controls personnel to be on site with TAB firm as needed to assist the TAB firm in completing the TAB work.
 4. The controls system installer shall also provide trending reports with the specific points and trend intervals, as requested by the TAB firm or engineer, when abnormal conditions are experienced.
 5. The scope of the TAB work, as defined herein, is indicated in order that the contractor will be apprised of their responsibility regarding the coordination and assistance required to complete the project requirements for final TAB. The TAB Firm will be responsible to the Engineer, and Owner for the satisfactory execution of the TAB services.

1.4 SERVICES OF THE TAB FIRM

A. TAB Firm Qualifications:

1. TAB Firm shall be one which is organized to provide independent professional testing, adjusting and balancing services. The firm shall have one (1) Professional Engineer licensed in the State of Texas, with current registration, on their staff. TAB Firm shall have operated a minimum of ten (10) years, under its current firm name.
2. All personnel used on the job site shall be either TAB engineers or TAB technicians, who shall have been permanent, full-time employees of the Firm for a minimum of one (1) year prior to working on this specific project.
3. TAB Firm shall submit the following to the Architect/Engineer and/or Owner for approval prior to commencing services:
 - a. Name and biographical data of the firms Professional Engineer and all other key personnel to be assigned to this project.
 - b. Proof of company operation for a minimum of ten (10) years.
 - c. Current AABC certification.
 - d. Documentation of number of full time staff size, specifically those personnel who perform or supervise the performance of TAB work.

B. TAB Firm Responsibilities:

1. Liaison: The TAB personnel on the job shall act as liaison between the Architect, Engineer, Owner and Contractor.
2. Inspect the installation of mechanical piping systems, sheet metal work, temperature controls and other component parts of the HVAC systems during the early construction stages, and at other appropriate stages, for the purpose of reviewing that part of the work relating to proper arrangement and adequate provisions for TAB.
3. When performing inspection services prepare a punch list to be copied to the Architect, Engineer and Contractor noting observed deficiencies that would prevent adequate access to equipment and components installed or missing that would prevent the TAB Services from being carried out successfully.

C. TAB Firm Services:

1. TAB personnel shall, upon completion of the installation and start-up of the mechanical equipment systems, test, adjust and balance the HVAC systems to provide optimum temperature, airflow and noise conditions in the conditioned spaces in the building while the HVAC equipment is operating efficiently.
2. The Firm shall be responsible for testing, adjusting, balancing and logging actual data on all air distribution and air moving equipment, water distribution and water circulating equipment, fans, pumps, heating and cooling equipment and the operating conditions of all motors, etc. as indicated in this specification.
 - a. Air Handling Units and Fan coil Units with and without Ducted Outside Air:
 - 1) Verify that the outside, return and relief air dampers are installed correctly, are fully operational and move freely.
 - 2) Verify that filters are new and clean, to include being the specified type, thickness and efficiency specified, at the time testing is performed.
 - 3) Verify correct fan rotation.
 - 4) If belt driven, verify proper belt tension and that fan and motor sheaves are properly aligned.
 - 5) Verify that all AHU safeties are operational (fire-stat, freeze-stat, etc.)
 - 6) Verify correct size and rating of motor overload protection (all phases as applicable).
 - 7) Verify fan motor is not overloaded; amperage readings do not exceed motor nameplate rating.
 - 8) Determine total supply and return air. Air quantities to be determined by duct traverse if duct configuration permits and air velocity is 800 to 1000 feet per minute or greater. If the duct main is not suitable for traverse then traverse branch ducts as required to total air flows supplied by the system.
 - 9) Balance air distribution system (see Air Distribution Devices.)
 - 10) If total air volume is less than design and motor capacity is available, adjust fan or fans and drives, as needed, to obtain supply and return

design CFM quantities to within + 10% of design. If new sheave or sheaves and belts are required, data will be submitted to Contractor for change out thereby. Then retest system to obtain design air quantities. Motors should be fully loaded if required to meet the tolerances specified herein.

- 11) Test and adjust the minimum outside air quantity up to any maximum values scheduled and return air CFM relationship to design.
- 12) Balance overall air distribution system (see air distribution devices).
- 13) Verify all temperature control devices are set and calibrated at design set point. Document sensor values as compared to a calibrated temperature test instrument and further record Energy Management System offsets programmed to obtain calibration requirements specified herein.

b. Air Distribution Devices:

- 1) Preset all volume dampers in the 100% open position.
- 2) Determine and verify proper air pattern deflection devices have been installed.
- 3) Verify size and types of all air devices installed, versus, the sizes and types indicated on the Drawings, to include neck sizes of diffusers.
- 4) Read out all air distribution devices served by their source (Fan Coil Units).
- 5) Balance all air distribution devices proportional to design CFM.
- 6) Adjust source to design CFM.
- 7) Verify that all air distribution devices are balanced to within plus or minus 10% of design (and all proportional to one another, + 10% from high to low, on each system even if the total cannot be within 10% of design).
- 8) Tolerances for 100% outside air ducts and outside air introduced through air handling equipment shall be +5% to -10%.

c. Fire, Fire-Smoke, and Smoke Dampers (Where applicable):

- 1) Verify operation of all fire-smoke and smoke dampers only by witnessing the Contractor fully opening and closing these dampers.
- 2) Verify each fire, fire-smoke, and smoke damper is located where indicated on the Drawings and tagged or identified with a permanent fire resistant tag or stencil (at access door location).
- 3) Verify that each fire, fire-smoke, and smoke damper is provided with a suitably sized and located access door to allow full testing and observation of damper operation. Verify each duct access damper has suitable access through general construction features.

- 4) Witness the Contractor testing each fire-smoke and smoke damper which shall be manually released, allowed to fully close, verifying it has a tight fit when closed, and then verify it does not bind when opening or closing.
 - 5) Witness each fire-smoke and smoke damper being fully opened by the Contractor and the fusible links on the fire damper portion of fire-smoke dampers being reset by the Contractor to include other related devices on smoke-fire dampers.
 - 6) Verify that all fire dampers are fully opened.
 - 7) Identify all dampers requiring repair or having a faulty installation.
 - 8) Write down pertinent information on damper testing tags to verify dates tested and initials of tester to confirm a successful test was conducted.
- d. Split Direct Expansion Air Conditioning Units:
- 1) Verify that the outside dampers are operational and move freely.
 - 2) Verify that filters are new and clean at the time of testing.
 - 3) Verify correct evaporator fan rotation.
 - 4) If belt driven, verify proper belt tension and that fan and motor sheaves are properly aligned. If direct drive, verify that motor is a multi-speed motor and adjust speed setting for air balance purposes unless a single speed fan is used in conjunction with a variable frequency drive or ECM drive.
 - 5) Verify that all equipment safeties are operational, as applicable, (anti-recycle timer, etc.).
 - 6) Verify correct size and rating of motor overload protection for each supply, return and relief fan motor.
 - 7) Verify each fan motor above is not overloaded; amperage readings do not exceed motor nameplate rating.
 - 8) Determine total supply and return air. Air quantities to be determined by duct traverse if duct configuration permits and air velocity is 800-1000 feet per minute or greater.
 - 9) Balance air distribution system (see Air Distribution Devices).
 - 10) If air volume is less than design and motor capacity is available, adjust fan or fans, to obtain supply and return design CFM quantities to within + 10% of design. If new sheave or sheaves and belts are required, data will be submitted to Contractor for change out. For direct drive fans, adjust fan speed setting. For fans served by variable frequency drives record fan speed and drive hertz at 100% design air flow. After adjustments are made, retest units to determine final air balance quantities.

- 11) Test and adjust the minimum outside air up to any maximum values scheduled and return air CFM relationship to design.
 - 12) Verify all temperature control devices are set and calibrated at design set points. Document sensor values as compared to a calibrated temperature test instrument and further record Energy Management System offsets programmed to obtain calibration requirements specified herein.
3. During the balancing process, all abnormalities or malfunctions of equipment or components discovered by the TAB personnel, will be reported promptly to the Engineer, Owner and Contractor so that the condition can be corrected expediently.
 4. The temperature controls will be verified for calibration and proper relationship between control devices. The Contractor will be advised of any instruments out of calibration so that the Automatic Temperature Controls (ATC) contractor can recalibrate, using data supplied by the TAB Firm as required.
 5. Thoroughly test the Energy Management System (EMS), as applicable. The testing of the Energy Management System shall include all HVAC controls, sensors, operators, sequences, etc. The tests shall include verification that commands introduced at the EMS console actually occur and temperatures, pressures, etc. indicated at the EMS console correlate with the actual reading at the sensing point. The ATC and EMS contractor shall provide technical support to the TAB Firm for a complete check out of the HVAC temperature controls and the Energy Management System. The EMS workstation console and field direct digital control panel displays of measured variables such as temperature, relative humidity, and pressure shall have the displayed values offset through software to be within 0.3 Deg. F. of the temperature, 5.0 percent for relative humidity and 0.01% for pressure of the actual variables measured in the field, with recently calibrated test equipment, at the sensor locations.
 6. After testing, adjusting and balancing to the design conditions, if comfort conditions are not being maintained, the air conditioning system shall be rebalanced within the limitations of the equipment installed to obtain comfort conditions. If comfort conditions cannot be obtained, a report will be submitted giving specific data regarding the trouble area.
 7. Make not less than three (3) inspections within ninety (90) days after occupancy of the building, and make adjustments if required, to insure that satisfactory conditions are being maintained throughout. Inspections are to be coordinated with Engineer, and Owner; and shall be documented with a supplemental report containing data and information, as required, after each visit, to document in writing that such visit took place and to note any unusual operating conditions.
 8. Make an inspection during the opposite season from that in which the initial adjustments were made and at that time make any necessary modifications to the initial adjustments required to produce optimum operation of the systemic components to produce the proper conditions in each conditioned space. The opposite season inspection shall be coordinated with the Engineer and Owner. This inspection shall be documented with a supplemental report containing any pertinent data and information regarding readings and adjustments made.

1.5 TAB REPORT

- A. TAB report shall incorporate all performance data for the HVAC systems. The intent of the final report is to provide a reference of actual operating conditions for the Owner's operating personnel.
- B. All measurements and recorded readings (of air, electricity, etc.) that appear in the report must be made on site by the permanently employed technicians or engineers of the TAB Firm.
- C. TAB report shall include but not be limited to the following:
 - 1. Index.
 - 2. Preface: A general discussion of the system, an outline of normal and ventilation modes of operation, any unusual operating conditions and any deficiencies not corrected as of the time the report was written.
 - 3. Instrumentation List: A list of instruments used by type, model, range and calibration date. All instruments must be calibrated within six (6) months prior to the starting date of TAB services.
 - 4. Air Handling Units, Fan Coil Units, etc.:
 - a. Manufacturer, model, size and serial number.
 - b. Design and actual CFM (Supply, Return and Outside).
 - c. Design and actual fan RPM.
 - d. Static pressure entering and leaving each filter bank, all coils and fans and other heat transfer components such as energy recovery wheels.
 - e. All motor nameplate data.
 - f. Motor starter data and motor overload protection (heater) sizes and rating for each motor.
 - g. Actual motor amperage and voltage (all phases) as compared to the nameplate data.
 - h. Filters; type, thickness, sizes, manufacturer, model number, MERV rating, quantities of each size and condition (new, clean, dirty, wet, etc.).
 - 5. Air Distribution Devices (Supply, Exhaust, and Return Air type where Balance Dampers are Used):
 - a. Manufacturer, model and size; include neck sizes for diffusers.
 - b. Location (Room name and number, ceiling, wall, etc.).
 - c. Design and actual CFM (cooling and heating).
 - d. Air distribution devices, where a velocity indicating instrument is used to determine CFM; provide the required and actual velocity in FPM (when an air flow hood is used to determine CFM, only CFM is required to be recorded.)
 - 6. Fire, Fire-Smoke, and Smoke Dampers:

- a. Fill out a tag (provided by the Contractor) at each damper with a set of the tester's initials and the date that the damper was tested and operation verified, as witnessed by the TAB firm, as being acceptable.
 - b. Tags shall have additional spaces for future testing/verification.
- 7. VRF System Indoor Units:
 - a. Manufacturer, Model, Size, and Serial Number.
 - b. Design and actual CFM (supply, return, and outside air).
 - c. Design and actual evaporator motor RPM.
 - d. Static pressure entering and leaving filters, coils, furnaces, and fans.
 - e. Evaporator motor name plate data.
 - f. Evaporator motor starter data and motor overload protection size and rating, or setting, for adjustable devices.
 - g. Actual evaporator motor amperage and voltage (all phases).
 - h. Filters; type, thickness, sizes, quantities of each size, and condition (new, clean, dirty, loaded, wet, etc.).
- 8. Condensing Units:
 - a. Manufacturer, Model, Size, and Serial Number.
 - b. Location.
 - c. Actual unit name plate data.
 - d. Actual unit (compressor and condenser unit motors) amperage and voltage, all phases.
 - e. Ambient air temperature entering condenser during indoor and outdoor unit testing.
- D. Instructions to Operating Personnel: TAB Firm shall instruct the operating personnel regarding the following:
 - 1. Systems Operation.
 - 2. Unusual Operating Conditions
 - 3. System Troubleshooting Procedures.
- E. Guarantee: Provide extended warranty of twelve (12) months after occupancy during which time the Engineer and/or Owner may, at his discretion, request check of the balance of any HVAC equipment. Provide TAB technicians to assist as required in making such tests. When any device is found not balanced in accordance with the mechanical plans and specifications, that HVAC system shall be completely rebalanced as directed by the Engineer and/or Owner at the TAB Firm's expense.

END OF SECTION

SECTION 23 07 00

INSULATION

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Owner's General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other portions of work.

1.2 SYSTEM DESCRIPTION

- A. Provide the systems of insulation which are specified for the control of heat transfer, sound control, and prevention of condensation.
- B. Provide protective devices to prevent compression abrasion or puncture of the piping insulation systems installed to include inserts, pipe shields, PVC jacketing and aluminum jacketing as specified herein.
- C. Provide piping identification systems as specified in Section 23 05 53, Mechanical Systems Identification for HVAC ductwork, equipment and piping.

1.3 QUALITY ASSURANCE

- A. The installation of all thermal insulation shall be performed by a single firm regularly engaged in the insulation business, using skilled insulation mechanics and using insulation materials which are the product of reputable manufacturers. The application of the materials by the insulator shall be in accordance with the published standards of the manufacturer of the materials, using any special materials as required by these specifications and by those published standards.
- B. Materials shall be manufactured by Schuller, Pittsburg Plate Glass, Owens-Corning, Foster, Childers, Certainteed, Johns Manville, or Knauf.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions to allow review of Materials and Methods to ensure complete compliance with specifications.
- B. Shop Drawings: Submit materials to be used and method of application for each system in tabular form. General statements not specifically identifying means or

methods to be used shall be cause for rejection. Include descriptive data and cut sheets on each type of insulation material, sealing method, adhesives used, insert types, shield sizes, and PVC or aluminum jacketing as specified.

1.5 PRODUCT HANDLING

- A. Cover and protect material in transit and at site. Material not properly protected and stored and which is damaged or defaced during construction shall and will be rejected.
- B. Promptly replace all damaged, deteriorated or wet insulation materials.
- C. Storage and protection of materials shall be in accordance with Section 23 05 00.

PART 2 - PRODUCTS

2.1 PIPING AND EQUIPMENT INSULATION MATERIALS

- A. Chilled and Heating Water Supply and Return Piping Insulation:
 - 1. Insulation shall be approximately 4 lb. or heavier in density, molded sectional glass fiber pipe covering with factory applied, white FRG, fire resistant, vapor barrier jacket.
 - 2. Insulate valves and fittings with pre-molded glass fiber fitting pipe insulators with ASJ manufactured by Knauf, Owens-Corning, Johns Manville, or Manson, equal in thickness to the adjoining pipe covering. Where pre-molded fitting insulators are not available, for welded pipe fittings insulate with field fabricated mitered segments of straight pipe insulation without ASJ equal in density and thickness to the adjoining pipe covering. Where pre-molded fitting insulators are not available for screwed or soldered/brazed pipe fittings insulate with field fabricated insulation which shall consist of loose low density glass fiber insulation wrapped and compressed tightly, equal in thickness and density to adjoining straight pipe insulation. Vapor seal with one 1/8" thick wet coat of Foster 30-33, Childers CP-33, or approved equivalent vapor barrier coating, placed over 10 x 10 strands per square inch glass fabric mesh which shall have an emulsion imbedded in it when applied. Apply a second of coating of 1/8" thick Foster No. 30-33, Childers CP-33, or approved equivalent adhesive applied over the mesh and first coating of vapor barrier. This coating application shall result in a minimum total dry film thickness of 37 mils. Vapor barriers - coatings shall have a maximum permeance rating of 0.07 at 43 mils dry film thickness per ASTM E-96, procedure B. Apply a PVC jacketing as specified elsewhere herein over all insulated valves and fittings.
 - 3. Valves, flow control valves, strainers and control valves may be insulated with contoured, custom cut, and fully glued one inch (1") thick Armaflex sheet or pipe insulation.
 - 4. Finish entire exposed straight pipe insulation installations with PVC sheet jacketing where exposed from the finished floor up to 12'-0" above the finished floor including all portions of horizontal piping that occurs at and extends above 12'-0". Jacketing shall be applied to all straight piping sections, as well as to all

elbows, tees, valves, flanges, fittings and other piping accessories. Use "smoke-safe" PVC fitting covers, similar to Speedline 1, Knauf "Proto" or Johns Manville "Zeston 2000." Suitably seal all jacketing seams with tape, or other approved means, along the entire length and butt joints of jacketing seams. Unless specifically noted otherwise, all PVC jacketing will be white in color.

5. Loose "Diaper" inserts at fittings shall not be allowed.
6. Insulation thickness shall be as follows (per the most recent version of the International Energy Conservation Code):

PIPING SYSTEMS	INSULATION THICKNESS - INCHES					
	PIPE SIZES					
	* RUNOUTS 3/4" & SMALLER	LESS THAN 1"	1" TO 1-1/2"	2" TO 3"	4" TO < 8"	8" and OVER
Heating Water (200 Deg. F. or less)	1.50	1.50	1.50	2.00	2.00	2.00
Chilled Water (40-60 Deg. F.)	1.50	1.50	1.50	1.50	1.50	1.50
* Runout piping for individual terminal or fan coil units not exceeding 4'-0" in length between the isolation valves and coils and not exceeding 3/4" in diameter.						

7. Chilled water and heating water lines in Main Mechanical Rooms may be covered with 0.016" aluminum jacketing from the finished floor to a point 8'-0" A.F.F., in lieu of PVC sheet jacketing, above 8'-0" PVC sheet jacketing required. All jacketing shall cover straight piping runs, elbows, valves and all other fittings.

B. Condensate Drains, Drains and Miscellaneous Lines:

1. The drain from each piece of Air Handling Equipment condensate drain pan and all refrigerant liquid and suction piping shall be insulated with foamed plastic, Armacell Armaflex or Aeroflex Aerocell slipped on while the piping is being fabricated, and with all joints, butt type, sealed using an adhesive recommended by the manufacturer of the plastic. The insulation shall be continuous from the drain opening in the Air Handling equipment condensate pan to the point of discharge with an open sight air gap over a drain. All formed plastic insulation shall meet ASTM E-84 requirements. Provide 1/ 2" thick insulation on condensate drains and 1-1/2" thick insulation on refrigerant suction piping. For all "Armaflex" type insulation installed outdoors apply two (2) coats of NOMACO K-Flex R-374, or Foster 30-64, or approved equal, protective coating (ultra-violet rays), white in color.

C. Plenum Safe Jacketing:

1. Where non-plenum rated piping (such as PVC, CPVC, FRP, PE, PP, ABS, PVDF, etc.) is installed in return air plenums cover all exposed portions of this piping with a plenum safe jacketing, or wrap, system that is a factory manufactured and tested non-combustible barrier, to flame and smoke spread, designed to encapsulate non-rated or combustible items located in return air plenums, in accordance with the most recent additions of the International Building and Mechanical Codes.
2. Plenum safe jacketing shall be covered with a light weight fiberglass reinforced foil scrim finished high temperature rated insulation with an approximate density of 6 pounds per cubic foot. Jacketing shall have a Flame Spread and Smoke Developed rating of 0 for the unfaced blanket and be under 25 and 50 respectively for these items as tested in accordance with U.L. 723 and ASTM E-84. Maximum Flame Spread in accordance with U.L.1887 shall be 0 feet. Maximum smoke/optical density and Average Smoke per U.L.1887 testing shall not exceed 0.1 and 0 respectively. U.L. 1887 test procedure is a modified tunnel test which provides test data for flame spread and smoke density using a single plastic pipe and a bundle of plastic pipes of various sizes subjected to a fire test.
3. Thermal resistance of the barrier system shall be 4.2 as tested in accordance with ASTM C518. The Barrier System shall be able to withstand an operating temperature up to 2,300 Deg. F. and have a melting point of no lower than 3,100 Deg. F.
4. Plenum safe jacketing shall be a minimum 1/2 inch thick and have at least one side covered with a foil skin which must face the outer, or exposed, side. All joints in each direction shall be overlapped a minimum of one inch (1"). Jacket shall be secured tightly around the piping with either stainless steel banding or stainless steel tie wire. Use stainless steel crimp clamps on banding fasteners. Tie wires shall be secured using twist tensioning. Seal all cut edges with aluminum foil tape to ensure there is no exposed fiber.
5. Plenum safe jacketing shall be as manufactured by:
 - a. FyreWrap by Unifrax, or approved equals by;
 - b. 3M Corporation.
 - c. Thermal Ceramics.

2.2 DUCTWORK INSULATION MATERIALS

A. Duct Insulation - External:

1. Concealed (above ceilings) external duct insulation shall be glass fiber blanket-type insulation of not less than 1 lb. per cu. ft. density with a factory applied flame-retardant vapor barrier facing. Facing shall consist of a layer of aluminum foil, reinforced layer of glass fibers, and a layer of kraft paper all bonded together with fire-retardant and adhesive. Insulation, adhesives, and tapes shall be rated in accordance with U.L. 181A or 181B. Minimum duct wrap insulation thickness shall be two inches (2") thick and be equal to Certainteed Type IV duct wrap.
2. All insulation systems shall meet the requirements of the most recent version of the International Energy Conservation Code, which requires a minimum installed R-value of 6.0 for conditioned, cooled or heated, and outside air system ductwork and

plenums when located inside buildings or spaces. Increase insulation thicknesses as required to comply.

3. Water Vapor Permeance shall be no greater than 0.05 Perms per ASTM-E-96.
4. Fire Hazard Classification of installed duct insulation systems shall meet the requirements of ASTM-E-84; Flame Spread of 25, or less; Smoke Developed and Fuel Contributed of 50, or less. All insulation systems, adhesives, mastics, sealants, and tapes shall be U.L. rated for the application. All tapes used shall be acrylic based.
5. All external duct insulation shall be a regularly manufactured product of one of the following:
 - a. Knauf.
 - b. Owens Corning.
 - c. Johns Manville.
 - d. Certainteed.
 - e. Manson.

B. Duct Insulation - Internal:

1. Internal duct insulation, liner, shall be in thicknesses as indicated herein, and be as specified in Specification Section 23 30 00. Duct liner shall be one inch (1") thick on all return, transfer, and relief air ducts, and on portions of general exhaust air ductwork systems as specified elsewhere herein. Internal duct insulation on all conditioned, cooled or heated, supply, all outside air ductwork systems and all mixed air plenums shall be 1-1/2" thick duct liner.
2. All duct liner shall be made of glass fiber coated with a bonded mat on the air stream side of the insulation. Coating shall be neoprene based meeting the requirements of NFPA-90A and U.L. Standard 723. Insulation shall not be less than 1.5 lbs. per cu. ft. density, and have a K-value of 0.28 per ASTM-C-177 at a mean temperature of 75 Deg. F.
3. All insulation systems shall meet the requirements of the most recent version of the International Energy Conservation Code, which requires a minimum installed R-value of 6.0 for conditioned, cooled or heated, supply and all outside air system ductwork and mixed air plenums when located inside buildings or spaces. Increase insulation thickness as required to comply.
4. Fire Hazard Classification of installed duct insulation systems shall meet the requirements of ASTM-E-84; Flame Spread of 25, or less; Smoke Developed and Fuel Contributed of 50, or less.
5. All insulation systems, adhesives, mastics, sealants, and tapes shall be U.L. rated for the application.
6. All duct liner shall be suitable for the air velocities to be encountered in each system, and shall generally be suitable for velocities of up to 6000 FPM.
7. Acceptable duct lining manufacturers shall be:
 - a. Certainteed.
 - b. Knauf.
 - c. Owens Corning.

- d. Johns Manville.
- e. Manson.

PART 3 - EXECUTION

3.1 GENERAL

- A. Apply insulation and pipe covering after all of the piping system to be insulated has been pressure tested, found to be completely tight (without leaks), and accepted as such. Verify that control valves and any other piping specialty where a valve stem or test port extends beyond the normal pipe insulation thickness to be installed is installed pointed upward vertically. Thoroughly clean and dry all surfaces prior to being covered. Refrigerant systems shall be turned off, refrigerant in piping shall have equalized with the average ambient temperature and all condensation shall be completely dried off of the pipe.
- B. For operational systems, perform work after operational hours and only during periods of scheduled equipment shutdown. During this period refrigerant flow to the piping segments to be insulated shall be stopped and the water and piping shall have equalized in temperature with the average ambient temperature of the space in which the piping is installed. If time does not permit this to occur then apply heat to the piping in a controlled, suitable manner, to warm the pipe sufficient to prevent any condensation from occurring during the insulation process. For any segments to be left uninsulated until the next system shutdown, mastic seal the ends and penetrations through of the installed insulation and allow sealant to dry prior to re-energizing the refrigerant system. Continue to insulate the piping system in small enough portions after-hours, or as required, to ensure no insulation is applied over a wet surface.
- C. In the covering of surfaces subject to low temperatures (below 60 Deg. F.), take extreme precautions to secure a complete vapor seal and avoid air pockets of any kind within the insulation. All insulation shall be tightly fitted to the piping system and all systems shall have an equal thickness and density of insulation around all piping, valves, strainers, accessories, etc. Where vapor barrier jackets are lapped at seams and joints, paste such flaps carefully to assure no break in the vapor seal. Seal around butt joints with strips of vapor barrier jacket. Coat all taped ASJ butt and longitudinal seams with vapor barrier coating to prevent moisture ingress. Use self-sealing laps on all insulation for pipes carrying a medium below 60 Deg. F. Stapling will not be permitted where vapor barrier jackets are specified. Vapor barriers for these systems shall have a perm rating not to exceed 0.05.
- D. Where jacketing systems are specified, use standard weight, PVC sheet rolls. Exercise care to locate seams in an inconspicuous place and apply all jacketing neatly, including

that on valves and fittings. Unsightly work will be considered a justifiable basis for rejection. Adhere the jacketing in all cases with a lagging adhesive, Foster 30-36 AF (Anti-Fungal) or Childers CP-137 AF, or by other approved methods. Adhesives shall have mold and mildew inhibitors. Lagging adhesives shall meet ASTM D 5590 with a "0" growth rating.

- E. All insulation shall be continuous through wall and ceiling openings and sleeves. Use exterior duct wrap insulation on the outside of smoke and fire damper sleeves. Create a secondary sleeve around the primary sleeve to allow a complete insulation system as allowed by the local authority having jurisdiction.
- F. All insulation and accessories shall have composite (insulation, jacket and adhesive used to adhere the jacket to the insulation) fire and smoke hazard ratings as tested under procedure ASTM E-84, NFPA 255, and UL 723 not exceeding:

Flame Spread	25
Smoke Developed	50
Fuel Contributed	50

- G. No insulation shall be applied to the bodies of unions and flanges on building heating water supply and return lines only. Terminate the insulation short of the unions or flanges at this equipment, and bevel off at a forty five degree angle to permit "breaking" the union or removal of the flange bolts without damaging the insulation. Bevel the insulation off also at caps on scale pockets, and blow-off connections on strainers, and at valve bonnets on these same systems. All valves, unions, flanges, strainer blow-off and drain caps for chilled water systems shall be fully insulated.
- H. Unsightly work shall be cause for rejection, including poor application of adhesives and coatings beyond the insulation which coats valves or other piping specialties.
- I. Damage or Modification to Insulation: Where new insulation is disturbed or damaged during the process of installing other new materials, making new connections, etc., it shall be repaired or replaced to return it to its original condition and appearance. Where lines are removed and connections to insulated lines are capped, insulate those caps as well as repairing damaged insulation. Materials shall match those presently installed in thickness, density, insulating value, jacketing, etc.
- J. Material Changes: Wherever there is a change in materials on lines that are vapor sealed, apply a suitable vapor barrier that is compatible with both materials, tapes, etc., as required to maintain the vapor barrier.
- K. The following describes materials, thickness and finishes for insulation on piping. In the following "exposed" shall mean any line or duct exposed below the finished ceiling and structure where no ceiling is installed, in any room space, area, mechanical rooms,

closets, and any line or duct run exterior to the building, including above the roof. "Concealed" shall mean any line or duct located above ceilings, in furrings, in chases, in crawl spaces, and buried in direct contact with the soil.

- L. In all "exposed" areas above the finished floor, insulation shall receive a PVC jacketing system. Neatly install all insulation systems not receiving jacketing such that they are suitable for finish painting.
- M. All insulation materials and jacketing shall exhibit the following characteristics:
 - 1. Water absorption, per ASTM C 1104, shall be less than 0.02%.
 - 2. Linear shrinkage, per ASTM C 356, shall be negligible.
 - 3. Stress corrosion, per ASTM C 795, shall not cause corrosion.
 - 4. Corrosiveness, per ASTM C 665, shall not be any greater than sterile cotton.
 - 5. Resistance to fungi, mold and mildew and bacteria, per ASTM C 665, shall be rated as not promoting growth of fungi and bacteria. Inhibitors shall be added to specified products to meet these requirements.

3.2 DUCTWORK

- A. Duct Insulation - Internal: Not Applicable.
- B. Duct Insulation - External:
 - 1. Externally insulate all rectangular and round supply and return air ducts not containing internal lining.
 - 2. Additionally insulate the outside of all fire, fire-smoke, and smoke damper sleeves penetrating walls and floors to insure a continuous insulation system.
 - 3. External insulation shall be applied in accordance with the manufacturer's recommendations by impaling over pins using speed clips or be secured with adhesive.
 - 4. Seal all joints, breaks, fastener penetrations and punctures with a 3" wide vapor barrier strip similar to that of facing materials secured with adhesive. Pins shall be spaced 12" on center both ways. Adhesive shall cover the entire duct surface.
 - 5. Blanket type insulation shall generally be used on concealed ductwork only with rigid insulation board being used exclusively on exposed ductwork, which shall also receive a PVC jacket when located above the finished floor.
 - 6. Vapor Seal all jacketing penetrations, cut openings, and cut edges and taped seams with an approved vapor barrier coating, Foster 30/33 or Childers CP-33 vapor barrier coating. All vapor barrier coatings shall have a maximum permeance rating of 0.07 or less at 45 mils dry per ASTM-E-96, procedure B.

3.3 SHIELDS AND INSERTS

- A. Metal saddles, shields, shall be applied between hangers or supports and the pipe insulation. Saddles shall be formed to fit the insulation and shall extend up to the centerline of the pipe and the length specified for hanger inserts. Shields shall be made

of galvanized sheet metal and shall be of sufficient size and length to prohibit the crushing of the insulation materials. Saddle shields shall be as follows:

Pipe Size	Metal Saddles	
	Metal Gauge	Length
3/4" to 3"	18	12"

END OF SECTION

SECTION 23 08 00

MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections, as applicable. Refer to other divisions for coordination of work with other portions of Work.

1.2 DESCRIPTION

- A. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
 - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
 - 2. Verify and document proper performance of equipment and systems.
 - 3. Verify that Systems and Operations and Maintenance (O&M) documentation is complete.
 - 4. Verify that the Owner's operating personnel are adequately trained in the O&M of these systems.
- B. The systems to be commissioned include: VRF HVAC systems and all related controls.
- C. Commissioning requires the participation of Division 23 and 26 system installers to ensure that all systems are operating in a manner consistent with the Contract Documents. Division 23 installers shall be familiar with all parts of the commissioning plan issued by the Commissioning Authority (C.A.) and shall execute all commissioning responsibilities assigned to them in the Contract Documents.
- D. Commissioning Team members shall consist of the Commissioning Authority (C.A.), the designated representative of the Owner, the General Contractor (GC, CM or Contractor), the architect and design engineers (particularly the mechanical engineer), the Mechanical Contractor (MC), the Electrical Contractor (EC), the Testing, Adjusting, and Balancing (TAB) representative, the Controls Contractor (CC), and any other installing subcontractors or suppliers of equipment pertinent to the complete installation of Division 23 and 26 Systems intended to be Commissioned. The Owner's building or plant operator is also a member of the commissioning team.

1.3 COMMISSIONING AUTHORITY

- A. The commissioning authority or agency shall be selected and employed by the building owner. The commissioning agent shall be a licensed professional engineer in the State where the work will be performed, and shall be experienced in the commissioning of mechanical and electrical systems of the type installed in this project. Experience in the construction process, direct digital control systems, Testing, Adjusting, and Balancing; and ASHRAE Guideline 1 – 2007 is mandatory. The commissioning agent shall not be associated with or employed by a mechanical contractor, or equipment supplier.

1.4 COMMISSIONING PLAN

- A. Commissioning Plan provides guidance in the execution of the commissioning process. Just after the initial commissioning scoping meeting the CA will provide the plan, which will continue to evolve and expand as the project progresses. The project Specifications shall take precedence over the Commissioning Plan.
- B. Commissioning Process includes a narrative that provides a brief overview of the typical commissioning tasks during construction and the general order in which they will occur.
 - 1. Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.
 - 2. Additional meetings will be required throughout the active construction phase, as scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
 - 3. Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures.
 - 4. The CA works with the pertinent subcontractors in developing startup plans and startup documentation formats, including pre-functional checklists to be completed, during the startup process.
 - 5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with pre-functional checklists being completed before functional testing.
 - 6. The Subcontractors, under their own direction, execute and document the pre-functional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This may include the CA witnessing start-up of selected equipment.
 - 7. The Subcontractors develop proposed specific equipment and system functional performance test (FPT) procedures. The CA will review these procedures and develop the official FPT procedures to be incorporated into the project.
 - 8. The procedures are executed by the Subcontractors, under the direction of, and documented by the CA.

9. Items of non-compliance in material, installation or setup are corrected at the Subcontractor's expense and the system is then retested.
10. The CA reviews the O&M documentation for completeness.
11. Commissioning is intended to be completed before Substantial Completion.
12. The CA reviews, pre-approves and coordinates the training provided by the Subs and verifies that it was completed.
13. Deferred testing is conducted, as specified or as required.

1.5 RESPONSIBILITIES

A. General Contractor (GC):

1. Facilitate the coordination of the commissioning work as outlined by the CA, and with the assistance of the CA, ensure that all commissioning activities are being scheduled into the master construction schedule.
2. Include all costs of commissioning, as outlined herein and elsewhere, in the total contract price.
3. Furnish one (1) copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to equipment to be commissioned to the CA.
4. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and complete training.
5. Ensure that all subcontractors execute their commissioning responsibilities according to the Contract Documents and schedule.
6. A representative shall attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Commissioning process.
7. Coordinate the training to be provided to the Owner's personnel.
8. Prepare O&M manuals and systems manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to "as-built" conditions.
9. Warranty Period:
10. Ensure that Subcontractors execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
11. Ensure that Subcontractors correct deficiencies and make necessary adjustments to O&M manuals and "as-built" drawings for applicable issues identified in any seasonal testing.

B. Mechanical and Controls Systems Installers:

1. Commissioning responsibilities applicable to each of the mechanical and controls (systems installers) of Division 23 are as follows (all references apply to commissioned equipment only):
 - a. Construction and Acceptance Phases:
 - 1) Include the cost of commissioning in the contract price.
 - 2) In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, Systems and O&M data and training.

- 3) Attend a commissioning scoping meeting and other meetings necessary to facilitate the Commissioning process.
- 4) Contractors shall provide the CA with normal cut sheets and shop drawing submittals of all equipment to be commissioned.
- 5) Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.
 - a) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
 - b) The Commissioning Agent may request further documentation necessary for the commissioning process.
- 6) Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.
- 7) Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- 8) Preparing proposed specific functional performance test procedures for submission to and consideration of the CA. The CA will use these submittals to prepare finalized test procedures. Subcontractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests, as applicable.
- 9) Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.
- 10) During the startup and initial checkout process, execute the mechanical-related portions of the pre-functional checklists for all commissioned equipment.
- 11) Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.

- 12) Address current A/E punch list items before functional testing. Air TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air related systems.
 - 13) Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
 - 14) Perform functional performance testing under the direction of the CA for specified equipment. Assist the CA in interpreting the monitoring data, as necessary.
 - 15) Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, and A/E and retest the equipment.
 - 16) Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to “as-built” conditions.
 - 17) Prepare redline “as-built” drawings for all drawings and final “as-builts” for contractor-generated coordination drawings.
 - 18) Provide training of the Owner’s operating personnel as specified.
 - 19) Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- b. Warranty Period:
- 1) Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
 - 2) Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

C. Mechanical (Systems Installer) Contractor:

1. The responsibilities of the HVAC mechanical contractor, during construction and acceptance phases in addition to those listed in (A) are:
 - a. Provide startup for all HVAC equipment, except for the building automation control system.
 - b. Assist and cooperate with the TAB contractor and CA by:
 - 1) Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - 2) Including cost of sheaves and belts that may be required by TAB.

- 3) Providing temperature and pressure taps in piping and equipment according to the Construction Documents for TAB and commissioning testing. Verify locations for taps with the CA before installation.
- c. Prepare a schedule for Division 23 equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
- d. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

D. Controls (Systems Installer) Contractor (CC):

1. The commissioning responsibilities of the controls contractor, during construction and acceptance phases in addition to those listed in (A) are:
 - a. Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
 - 1) An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
 - 2) All interactions and interlocks with other systems.
 - 3) Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
 - 4) Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
 - 5) Start-up sequences.
 - 6) Warm-up mode sequences.
 - 7) Normal operating mode sequences.
 - 8) Unoccupied mode sequences.
 - 9) Shutdown sequences.
 - 10) Capacity control sequences and equipment staging.
 - 11) Temperature and pressure control: setbacks, setups, resets, etc.
 - 12) Detailed sequences for all control strategies, e.g., optimum start/stop, staging, optimization, demand limiting, etc.
 - 13) Effects of power or equipment failure with all standby component functions.
 - 14) Sequences for all alarms and emergency shut downs.
 - 15) Seasonal operational differences and recommendations.
 - 16) Initial and recommended values for all adjustable settings, set points and parameters that are typically set or adjusted by operating staff; and any

other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.

- 17) All sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.
- b. Control Drawings Submittals shall include:
- 1) Control drawings shall have a key to all abbreviations.
 - 2) Control drawings shall contain graphic schematic depictions of each system and each component.
 - 3) Schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - 4) Provide a full points list with at least the following included for each point:
 - a) Controlled system.
 - b) Point abbreviation.
 - c) Point description.
 - d) Display unit.
 - e) Control point or set point (Yes / No).
 - f) Monitoring point (Yes / No).
 - g) Intermediate point (Yes / No).
 - h) Calculated point (Yes / No).
 - i) Key:
 - (1) Point Description: DB temp, airflow, etc.
 - (2) Control or Set point: Point that controls equipment and can have its set point changed (OSA, SAT, etc.)
 - (3) Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
 - (4) Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
 - (5) Calculated Point: "Virtual" point generated from calculations of other point values.
 - 5) Controls Contractor shall keep the CA informed of all changes to this list during programming and setup.
- c. An updated "as-built" version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
- d. Assist and cooperate with the TAB contractor in the following manner:

- 1) Meet with the TAB contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.).
 - 2) Have all required pre-functional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.
 - 3) Provide a qualified technician to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
- e. Assist and cooperate with the CA in the following manner:
- 1) Execute the functional testing of the controls system as specified for the controls contractor.
 - 2) Assist in the functional testing of all equipment specified.
- f. Controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
- 1) System name.
 - 2) List of devices.
 - 3) Step-by-step procedures for testing each controller after installation, including:
 - a) Process of verifying proper hardware and wiring installation.
 - b) Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - c) Process of performing operational checks of each controlled component.
 - d) Plan and process for calibrating valve and damper actuators and all sensors.
 - e) A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - 4) A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
 - 5) A description of the instrumentation required for testing.

- 6) Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB contractor for this determination.
 - g. Provide a signed and dated certification to the CA and CM or GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing for each piece of equipment or system, that all system programming is complete as to all respects of the Contract Documents, except functional testing requirements.
 - h. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.
 - i. List and clearly identify on the “as-built” duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).
- E. TAB Contractor. The duties of the TAB contractor, in addition to those listed in (A) are:
- 1. Submit the outline of the TAB plan and approach for each system and component to the CA prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
 - 2. Submitted plan will include:
 - a. Reviewed the construction documents and the systems to sufficiently understand the design intent for each system.
 - b. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - c. Detailed step-by-step procedures for TAB work for each system and issue.
 - d. Plan for formal deficiency reports (scope, frequency and distribution) and final report.
 - 3. Submit reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA as required.
 - 4. Communicate to the controls contractor all set point and parameter changes made or problems and discrepancies identified during TAB, which affect the control system setup and operation.
 - 5. Provide a draft TAB report to the CA. The report should follow the latest reporting recommendations by AABC.
 - 6. Provide the CA with any requested data, gathered, but not shown on the draft reports.
 - 7. Provide final TAB reports in the number required.
- F. Equipment Suppliers:
- 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 - 2. Assist in equipment testing per agreements with Subs.

3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the Contractor, except for stand-alone data logging equipment that may be used by the CA.
4. Provide information requested by CA regarding equipment sequence of operation and testing procedures.
5. Review test procedures for equipment installed by factory representatives.

G. Commissioning Agent (CA):

1. The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving non-conformance items or deficiencies, but ultimately that responsibility resides with the general contractor and the A/E. The primary role of the CA is to develop and coordinate the execution of a testing plan, observe and document performance so that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. Contractor and all subcontractors shall provide all tools or the use of tools to start, checkout and functionally test equipment and systems, to include any specified or required testing equipment needed to conduct these tests.
2. Construction Phase:
 - a. Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
 - b. Coordinate the commissioning work and, with the GC, ensure that commissioning activities are being scheduled into the master schedule.
 - c. Revise, as necessary, Commissioning Plan—Construction Phase.
 - d. Plan and conduct a commissioning scoping meeting.
 - e. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures.
 - f. Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
 - g. Review normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, along with A/E reviews.
 - h. Assist in the development of pre-functional tests and checklists.
 - i. Assist in the development of an enhanced start-up and initial systems checkout plan with Subcontractors.

- j. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
 - k. Witness all or part of the HVAC piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's project manager of any deficiencies in results or procedures.
 - l. Witness all or part of any ductwork testing and cleaning procedures, if required, sufficient to be confident that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify owner's project manager of any deficiencies in results or procedures.
 - m. Approve pre-functional tests and checklist completion by reviewing pre-functional checklist reports and by selected site observation and spot-checking.
 - n. Approve systems startup by reviewing start-up reports and by selected site observation.
 - o. With necessary assistance and review from installing contractors, review the functional performance test procedures for equipment and systems. This may include energy management control system trending, or manual functional testing.
 - p. Analyze any functional performance trend logs and monitoring data to verify performance.
 - q. Coordinate, witness and approve manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
 - r. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.
 - s. Oversee and approve the training of the Owner's operating personnel.
 - t. Compile and maintain a commissioning record and building systems book(s).
 - u. Review and approve the preparation of the O&M and Systems manuals.
 - v. Provide a final commissioning report.
3. Warranty Period:
- a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
 - b. Return to the site at 10 months into the 12-month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also

interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

1.6 SCHEDULING

- A. The CA will work with the GC according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the CM and GC for scheduling commissioning activities.
- B. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the applicable Division 23 or 26 contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 23, except for equipment specific to and used by the TAB firm in their commissioning responsibilities.
- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents, shall be included in the Base Bid price of the Contractor and be left on site.
- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of + or - 0.5°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed to the test equipment or certificates of calibration shall be readily available with a copy being furnished to the C.A. for their records.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Scoping Meeting. Within 90 days of commencement of construction, the CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the GC. Information gathered from this meeting will allow the CA to revise the Commissioning Plan to its “final” version, which will also be distributed to all parties.
- B. Miscellaneous Meetings will be planned and conducted by the CA as required as the construction phase progresses. These meetings will cover coordination, deficiency resolution and planning issues with particular Subcontractors. The CA will plan these meetings and will minimize unnecessary time being spent by Subcontractors, or any other member of the Commissioning Team.

3.2 REPORTING

- A. CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
- B. Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.
- C. A final summary report by the CA will be provided focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Pre-functional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

3.3 SUBMITTALS

- A. CA will provide appropriate contractors with a specific request for the type of submittal documentation the CA requires to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer’s printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to

the Commissioning Agent. All documentation requested by the CA will be included by the Subs in their O&M manual contributions.

- B. Commissioning Agent will be given the opportunity to review all pertinent submittals related to equipment or systems to be commissioned for conformance to the Contract Documents, and more specifically as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning Agent will notify the appropriate persons as requested, of items missing or areas that are not in conformance with Contract Documents as it relates to the commissioning process, and which require resubmission.
- C. CA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.
- D. Submittals sent to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, although the CA will review them.

3.4 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned. Some systems that are not comprised so much of actual dynamic machinery may have very simplified PCs and startup.
- B. Pre-functional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout. No sampling strategies are used. The pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- C. Start-up and Initial Checkout Plans will be required by the CA who shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for pre-functional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements.

1. Checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
 2. Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form may have more than one trade responsible for its execution.
 3. Each Subcontractor responsible for the purchase of each item of equipment shall develop the full start-up plan for that equipment by combining (or adding to) the CA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan. The full start-up plan could consist of something as simple as:
 - a. Pre-functional checklists developed jointly by the CA and the subcontractors.
 - b. Manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
 - c. Manufacturer's normally used field checkout sheets.
 4. Each Subcontractor shall submit the full startup plan for which they are responsible to the CA for review and approval.
 5. CA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.
 6. Full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.
- D. Sensor Calibration of all sensors shall be included as part of the pre-functional checklists performed by the Contractors, according to the following procedures:
1. Sensors without Transmitters, Standard Application type, shall include taking readings with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

Sensor	Required Tolerance (+/-)		Sensor	Required Tolerance (+/-)
RTU wet bulb or dew point	1.0 Deg. F.		Flow rates, air	10%of design
Indoor and outdoor air pressure differential	0.05 Inches W.G.		Pressures, air	5% of design
Outside air, space air, coil air temps	1.0 Deg. F.		Watt-hour, voltage & amperage	2%

E. Execution of Pre-functional Checklists and Startup.

1. Four weeks prior to startup, the Subcontractors and pertinent vendors shall schedule startup and checkout with the GC and CA. The performance of the pre-functional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off pre-functional checklists, signatures may be required of other Subs for verification of completion of their work.
2. CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved).
3. For lower-level components of equipment, (e.g., fans, sensors, controllers), the CA shall observe a sampling of the pre-functional and start-up procedures. The sampling procedures are identified in the commissioning plan.
4. Subcontractors and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and pre-functional tests and checklists.
5. Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off. It is not acceptable for supervisors to fill out these forms if they have not witnessed the test.

F. Deficiencies, Non-Conformance and Approval in Checklists and Startup:

1. Subcontractors shall clearly list any outstanding items of the initial start-up and pre-functional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.
2. CA reviews the report and submits either a non-compliance report or an approval form to the Sub or GC. The CA shall work with the Subcontractors and vendors to correct and retest deficiencies or uncompleted items. The CA will involve the GC and others as necessary. The installing Subcontractors or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original

non-compliance report. When satisfactorily completed, the CA recommends approval of the execution of the checklists and startup of each system using a standard form.

3.5 FUNCTIONAL TESTING

- A. This sub-section applies to all commissioning functional testing for all Divisions.
- B. Objectives and Scope of functional testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, no flow, equipment failure, etc. shall also be tested.
- C. Development of Written Test Procedures shall begin with the CA obtaining all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CA shall then, with the assistance the contractor, develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Subcontractor or vendor responsible to execute a test, shall provide assistance to the CA in developing the procedures (answering questions about equipment, operation, sequences, etc.). Prior to execution, Subcontractors shall review the tests for feasibility, safety, equipment and warranty protection. The CA may submit the tests to the A/E for review, if requested. The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.
- D. Test Methods shall include the following:
 - 1. Functional testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CA will determine which method is most appropriate for tests that do not have a method specified.
 - 2. Simulated Conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
 - 3. Altering Set points rather than overwriting sensor values, and when simulating conditions is difficult, altering set points to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature

- below 55F, when the outside air temperature is above 55F, temporarily change the lockout set point to be 2F above the current outside air temperature.
4. Setup of each function and testing shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
- E. Coordination and Scheduling by the Subcontractors shall provide sufficient notice to the CA regarding their completion schedule for the pre-functional checklists and startup of all equipment and systems. The CA will schedule functional tests through the GC and affected Subcontractors. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subcontractors shall execute all tests. In general, functional testing is conducted after pre-functional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation by the CA shall include witnessing and documenting the results of all functional tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the GC for review. CA will include the filled out forms in the Commissioning Report.
- B. Non-Conformance.
1. CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported on a standard non-compliance form.
 2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.
 3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.
 4. As tests progress and a deficiency is identified, the CA discusses the issue with the executing contractor.

- a. When there is no dispute on the deficiency and the Subcontractor accepts responsibility to correct it:
 - 1) CA documents the deficiency and the subcontractor response and intentions and they go on to another test or sequence
- b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1) The deficiency shall be documented on the non-compliance form with the Subcontractor's response and a copy given to the GC and to the Subcontractor representative assumed to be responsible.
 - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Owner.
 - 3) The CA documents the resolution process.
 - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CA. The CA reschedules the test and the test is repeated until satisfactory performance is achieved.
- 5. Cost of Retesting for the Subcontractor to retest a pre-functional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
- 6. Contractor shall respond in writing to the CA at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
- 7. CA retains the original non-conformance forms until the end of the project.
- C. Approval by the CA shall include notation of each satisfactorily demonstrated function on the test form. CA recommends acceptance of each test using a standard form. The Owner gives final approval on each test using the same form, providing a signed copy to the CA and the Contractor.

3.7 SYSTEMS and OPERATION AND MAINTENANCE (O&M) MANUALS

- A. Following System and O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.
- B. Division 23 shall compile and prepare documentation for all equipment and systems covered in Division 23 and deliver this documentation to the GC for inclusion in the O&M manuals, according to this section, prior to the training of owner personnel.
- C. CA shall receive a copy of the Systems/O&M manuals for review.

- D. Special Control System O&M Manual Requirements shall include, in addition to documentation that may be specified elsewhere, the controls contractor compiling and organizing, at minimum, the following data on the control system in labeled 3-ring binders with indexed tabs:
1. Three (3) copies of the controls training manuals in a separate manual from the O&M manuals.
 2. Operation and Maintenance Manuals containing:
 - a. Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tables of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included if required in the controls specification section.
 - b. Full as-built set of control drawings.
 - c. Full as-built sequence of operations for each piece of equipment.
 - d. Full points list. In addition to the updated points list required in the original submittal.
 - e. Full print out of all schedules and set points after testing and acceptance of the system.
 - f. Full as-built print out of software program as required.
 - g. Electronic copy on disk of the entire program for this facility if required.
 - h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
 - i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
 - j. Control equipment component submittals, parts lists, etc.
 - k. Warranty requirements.
 - l. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
 3. Manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
 - a. Sequences of operation.
 - b. Control drawings.
 - c. Points lists.
 - d. Controller / module data.
 - e. Thermostats and timers.
 - f. Sensors and DP switches.
 - g. Valves and valve actuators.
 - h. Dampers and damper actuators.

- i. Program setups (software program printouts).
- 4. Field checkout sheets and trend logs should be provided to the CA for inclusion in the Commissioning Record Book.
- E. Review and Approval of the commissioning related sections of the Systems and O&M manuals shall be made by the A/E and the CA.

3.8 TRAINING OF OWNER PERSONNEL

- A. GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.
- B. CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.
- C. Mechanical Contractor shall have the following training responsibilities:
 - 1. Provide the CA with a training plan two weeks before the planned training.
 - 2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.
 - 3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 - 4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 - 5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
 - 6. Controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
 - 7. Training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 - 8. Training shall include:
 - a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - b. A review of the written Systems/O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed

and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.

- c. Discussion of relevant health and safety issues and concerns.
 - d. Discussion of warranties and guarantees.
 - e. Common troubleshooting problems and solutions.
 - f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - g. Discussion of any peculiarities of equipment installation or operation.
 - h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1- 2007 is recommended.
 - i. Classroom sessions shall include the use of overhead projections, slides, and video/audio-taped material as might be appropriate.
9. Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.
 10. Mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
 11. Duration of Training by the mechanical contractor shall include providing training of sufficient length on each piece of equipment according to the requirements of the preceding specification sections. If not listed in the equipment sections, the following schedule shall be used.

<u>Hours</u>	<u>System</u>
<u>5</u>	Rooftop Units
<u>2</u>	Heating System
<u>4</u>	Specialty Exhaust Fans/Systems (such as Plymovent in an Apparatus Bay)
<u>1</u>	Restroom Central Exhaust Fans
<u>2</u>	Others???????

D. Controls Contractor shall have the following training responsibilities:

1. Provide the CA with a training plan four weeks before the planned training.
2. Controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
3. Training manuals shall include the standard operating manual for the system and any special training manuals which shall be provided for each trainee, with three extra copies left for the O&M manuals. In addition, copies of the system technical manual will be demonstrated during training and three copies submitted with the O&M manuals. Manuals shall include detailed description of the subject matter for each session. The manuals will cover all control sequences and have a

- definitions section that fully describes all relevant words used in the manuals and in all software displays. Copies of audiovisuals shall be delivered to the Owner.
4. Training will be tailored to the needs and skill-level of the trainees.
 5. Trainers will be knowledgeable on the system and its use in buildings. The Owner shall approve the instructor prior to scheduling the training.
 6. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 7. Controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
 8. There shall be three training sessions:
 - a. Training I - Control System: The first training shall consist of 24 hours of actual training. This training may be held on-site or in the supplier's facility. If held off-site, the training may occur prior to final completion of the system installation. Upon completion, each student, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - b. Training II - Building Systems: The second session shall be held on-site for a period of 8 hours of actual hands-on training after the completion of system commissioning. The session shall include instruction on:
 - 1) Specific hardware configuration of installed systems in this building and specific instruction for operating the installed system, including HVAC systems, lighting controls and any interface with security and communication systems.
 - 2) Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing set points and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - 3) All trending and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends. Trainees will actually set-up trends in the presence of the trainer.
 - 4) Every screen shall be completely discussed, allowing time for questions.
 - 5) Use of keypad or plug-in laptop computer at the zone level.
 - 6) Use of remote access to the system via phone lines or networks if included.
 - 7) Setting up and changing an air terminal unit controller.

- c. Training III - General Overview: The third training will be conducted on-site six months after occupancy and consist of 8 hours of training. The session will be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.
- E. TAB contractor shall have the following training responsibilities:
 - 1. TAB shall meet for 2 hours with facility staff after completion of TAB and instruct them on the following:
 - a. Go over the final TAB report, explaining the layout and meanings of each data type.
 - b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
 - c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
 - d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
 - e. Other salient information that may be useful for facility operations, relative to TAB.

3.9 WRITTEN WORK PRODUCTS

- A. Written work products of Contractors will consist of the start-up and initial checkout plan described and the filled out start-up, initial checkout, pre-functional, and functional checklists, training plans and records of training. These work products will be supplied to the CA to be included in the final commissioning report.

END OF SECTION

SECTION 23 09 00

CONTROLS AND INSTRUMENTATION

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Owner's General Requirements and all referenced documents.
- B. Comply with Sections 23 00 00 and 23 05 00, General Provisions, and all other Division 23 Sections, as applicable.
- C. Refer to other Divisions for coordination of work with other trades.

1.2 SYSTEM DESCRIPTION

- A. BAS Open System Design and Qualifications
 - 1. Open System Design: It is the owners expressed goal to implement an open Building Automation System that will allow products from different manufacturers and/or suppliers to be integrated into a single unified system in order to provide flexibility for expansion, maintenance, and service of the system. The BAS manufacturer / contractor must provide proof of open system design as outlined below.
 - 2. Prior to award of the contract the BAS contractor is to provide proof of "Open System Design" with the following requirements:
 - a. Provide proof of having a local office within 25 miles of the project site for at least five (5) years, staffed by trained personnel capable of providing installation, engineering, programming, servicing, commissioning, instruction, routine maintenance, and emergency service on systems.
 - b. The controls system shall utilize the Niagara4 software framework.
 - 1) The Contractor shall have a minimum of five (5) years' experience in the sales, installation, engineering, programming servicing and commissioning of Niagara4.
 - 2) Submit the Niagara Compatibility Statement (NiCS) via a letter from the manufacturer. The NiCS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of "All").

- c. The controls system shall conform to the following guidelines for communication protocols.
 - 1) BACnet shall be used for all BAS provided controllers.
 - a) The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (<https://www.bacnetinternational.net/btl/search.php>)
 - b) The use of BACnet Communications protocol alone shall NOT warrant an “Open System Design.” Manufacturers must adhere to all aspects of “BAS Open System Design and Qualifications” and “Acceptable System Manufacturers” sections to comply.
 - 2) Modbus shall only be acceptable for third party devices.
 - 3) Fox protocol shall NOT be acceptable.
 - 4) Proprietary communications protocols shall NOT be acceptable.
- d. A software programming tool shall be provided for this project and adhere to the following guidelines:
 - 1) All software tools needed for full functional use, including programming of controllers, Niagara4 Framework network management and expansion, and graphical user interface use and development, of the BAS described within these specifications shall be provided to the owner or their designated agent.
 - 2) The software programming tool shall be free of charge and be openly available for download from the internet.
 - 3) For any manufacturer that does not have a free programming tool the manufacturer must provide the tool with this project for a minimum of five (5) years with proof of availability via letter from the manufacturer.
 - 4) Any licensing required by the manufacturer now and through the completion of the warranty period, including changes to the licensee of the software tools and the addition of hardware corresponding to the licenses, shall allow for a complete and operational system for both normal day to day operation and servicing shall be provided.

B. Acceptable System Manufacturers and Contractors

- 1. Provide a building automation system supplied by a company regularly engaged in the manufacturing and distribution of building automation systems for a minimum of five (5) years.
- 2. The manufacturer of the hardware and software components shall have a technical support group accessible via a toll-free number that is staffed with qualified

- personnel, capable of providing instruction and technical support service for networked control systems.
3. BACnet/IP communication protocol must be used for all BAS manufacturer provided controllers (including terminal devices such as A/C Units, Fans, etc.)
 4. Any approved manufacturer that can supply both equipment and controls must provide controls pricing separately from equipment pricing.
 5. Acceptable Manufacturers
 - a. Enviromatic Systems, using Reliable Controls.
 - b. JMS Integrated Building Solutions, using Distech Controls.
- C. Only certified Niagara Framework based open system components are acceptable for the overall Integrated Automation System (IAS).
- D. The Owner shall be named the license holder of all software products associated with any work on the project.
- E. The scope shall include the furnishing, installing and commissioning of a new Niagara Framework with BACnet, fully programmable, which shall be integrated to the control system controllers furnished by others as specified herein, which will be installed in this facility. Furnish a JACE panel as required to interface the Niagara front end to the building system controls, Reliable or Distech.
- F. Provide all digital controllers and make all connections to all local and remote control panels, temperature control field devices, appurtenances, etc., to accomplish specific control sequences specified herein, to provide fire and freeze protection; cocks and wells for various temperature and pressure control, sensing and indicating devices; pressure and temperature indicating instruments; supporting structures, and other required components for a complete and operating system.
- G. Provide certified Niagara Framework based products that communicate on free topology channels (BACnet IP is also acceptable) to meet the functional specifications.
- H. The scope shall include all new electric connections to new thermostats, sensors, dampers, actuators, switches and relays, and all other new components of the system requiring electric connections.
- I. The scope shall further include all temperature control and interlocking wiring and wiring devices, including raceways, as indicated herein.
- J. Furnish and install all low voltage step-down transformers and associated connections, power supplies and cabling necessary for the controls system.
- K. Provide all software programs as required to produce the sequences of control, monitoring, reporting, etc., as indicated herein.

- L. Provide Graphical User Interface (GUI) development for all devices identified within this section and shown on the drawings.
- M. The new controls system installed shall be fully automatic, subject to various types of remote surveillance, routine remote adjustments, remote status, remote alarms, remote data collection for trending/historical files, and other operations as indicated herein, from a new local remote microprocessor-based Local Area Network (LAN), with the local system capable of stand-alone operation.
- N. The controls system shall be capable of being monitored and controlled by the Owner's existing off-site Central Workstation via the Owner's WAN, or Ethernet LAN, or other communication format. Verify with the Owner what all is required to utilize their front end system. Add to or upgrade this system as required to allow this system to be fully functional.
- O. Bidders are specifically advised that full and effective two-way communication between the new system installed under this contract and the Owner's Central Workstation must be achieved in an approved manner, including whatever may be required in the form of interface hardware and software without effecting or interrupting other system software. Simultaneous on-line communication of this system and others with the Central EMS is mandatory.
- P. This system of equipment and software (Niagara Framework) shall be provided and installed by a local factory trained and authorized sales, installation and service agent of the following equipment providers:
 - 1. Reliable Controls.
 - 2. Distech Controls.

1.3 QUALITY ASSURANCE

- A. The equipment provided under this Section of the Specifications shall be installed, calibrated, adjusted, and put in completely satisfactory operation by a Control Systems installer experienced in this type of work.
- B. The successful Control Systems installer shall meet the following requirements:
 - 1. All spare parts must be locally stocked and readily available within a 24 hour period.
 - 2. Service personnel shall be available, on call, on a 24 hour a day, year round basis, or service personnel will respond by visitation to the site within four (4) hours of a service call considered serious in nature or classified by the Owner as an emergency.
 - 3. Be able to provide evidence of having successfully installed similar sized and types of systems for a minimum of ten (10) years.

4. Bids by wholesalers, distributors, mechanical contractors and non-franchised contractors shall not be acceptable.
 5. All work described in the Plans and Specifications shall be installed, wired, and commissioned by factory certified technicians qualified for this work and in the regular employment of the control system manufacturer's local office.
 6. A local office is defined as a corporate branch office or an independently owned office with a current contractual agreement with the system manufacturer that allows the office to purchase, install, and service the manufacturer's products.
 7. The local office shall be full-service facility within 25 miles of the project site. The local office shall be staffed with engineers and technicians trained on the installation, commissioning, and service of energy management and control systems.
- C. All control devices shall be as specified in the technical portion of this section of the specifications. The system shall be installed by workmen skilled, experienced, and specifically trained in the application, installation, calibration, adjusting, and testing of instrumentation of the type specified.
- D. All control system components shall operate satisfactory without damage at 110% above and 85% below rated voltage and at + 3 hertz variation in line frequency. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients and induced magnetic interference. All bus connected devices shall be A.C. coupled, or equivalent, so that any single device failure will not disrupt or halt bus communications. Provide line voltage input protection to all network level controllers to protect these devices from over-voltage and lightning strike conditions.
- E. A service representative of the installer shall check the instrumentation for proper installation, calibrate all instruments and make all adjustments necessary to ensure proper operation of the system in full cooperation with the Testing, Adjusting, and Balancing (TAB) Firm. Refer to Section 23 05 93. All instruments required for checking, calibrating, and proving the system shall be provided under this Section of the Specifications. The service representative shall spend sufficient time with all of the Owner's Representatives after the system is installed and properly functioning to instruct the Owner's Representative (Operations and Maintenance Personnel) in the operation of the system for a minimum of four (4) hours for the basic Controls System and four (4) hours for the EMS. At final completion of the installation provide personnel and instruments of satisfactory quality available to check the calibration of all instruments, and to demonstrate system operation as described in "Sequences of Operation".
- F. All basic control devices, parts, and other materials shall be standard catalog products of a single reputable manufacturer and shall essentially duplicate equipment which has been in satisfactory service for at least one (1) year. All materials and parts shall be

items in current production by the manufacturers. First of a kind, new technology devices, will not be considered. Accessory equipment that is required to make a complete and functioning system that is not of the same manufacturer furnishing the basic control equipment shall carry the guarantee of the basic control equipment manufacturer and repair and replacement parts shall be available through normal local trade channels.

- G. All software updates and enhancements which evolve during the first-year warranty period following system acceptance, "Substantial Completion", shall be furnished to the Owner without additional cost. This shall include the local stand-alone direct digital controllers and the building network manager computer(s).
- H. Furnish an extended one (1) year warranty beyond the standard one (1) year warranty for all EMS components to specifically include all electronic components and control devices associated therewith. All warranties shall commence officially on the date of Substantial Completion, the date to be determined by the Engineer and Owner.
- I. All network level controllers shall be either native "ASHRAE BACnet" and shall communicate with all other BACnet communication systems at the building network level or be provided with a gateway which shall facilitate the building network level controller communicating with one of these systems.

1.4 SYSTEM START-UP AND COMMISSIONING

- A. After completion of the installation, Contractor shall place the system in operation and shall perform all necessary testing and debugging operations of the basic systems and EMS.
- B. An acceptance test shall be performed in the presence of the Testing, Adjusting, and Balancing (TAB) Company, to verify correct sequences of operation, calibration, and operation of the Controls and Energy Management System, when installed, with every part of the system functioning satisfactorily and having been fully commissioned, and with no outstanding items requiring completion or correction, the system will be accepted by the Architect and Owner for "Substantial Completion", and will then be placed under Warranty.
- C. The Automatic Temperature Control and Energy Management System Installer shall thoroughly check all controls, sensors, operators, sequences, etc., before notifying the TAB Agency that the Automatic Temperature Controls and Energy Management System are operational. The Automatic Temperature Control and Energy Management System Installer shall provide technical support (technicians and necessary hardware and software) to the TAB Agency to allow for a complete check-out of these systems.

1.5 SUBMITTALS

- A. Submittals shall be complete and be in full accordance with Section 23 05 00, Common Work for HVAC.
- B. Submittals shall include complete, continuous line, point to point wiring diagrams including tie-in points to equipment with written sequences of control adjacent to pertinent control diagrams. Specification sheets shall be submitted on each piece or type of equipment in a separate brochure and show sufficient detail to indicate compliance with these specifications. Drawings and Specification sheets shall show set points, throttling ranges, actions, proportional bands, and integration constants, where applicable. Complete brochures shall include the wiring diagrams as well as operating and maintenance instructions on the equipment.
- C. Complete and approved shop drawings shall be obtained prior to commencing installation work, unless otherwise approved by the Owner or Owner's Representative.
- D. Tag numbers, as shown or specified, shall appear for each item on the wiring diagrams and data sheets. Data sheets shall properly reflect in every detail the specific item submitted.
- E. After completion of the work, Contractor shall prepare and furnish maintenance brochures for the Owner. The maintenance brochures shall include operating instructions, specifications, and instruction sheets for all instruments and a complete set of "As-Built" control drawings. After approval of submittal, completion of all installation work, software checkout, and system commissioning in conjunction with the Testing, Adjustment and Balance (TAB) Firm, furnish to the Owner the following:
 - 1. Three (3) sets of "As-Built" drawings, (11" X 17" sheets), inserted in a three ring binder.
 - 2. Three (3) copies of the final approved Shop Drawings in suitably sized three ring binders. This shall include copies of product data sheets and other operations and maintenance documentation.
 - 3. A complete replacement spare parts list.
 - 4. A back-up of the EMS settings and sequences of operation on a USB flash drive. The flash drive shall include all of the files necessary to restore the EMS and controls system to normal operation in the event of a system failure.
 - 5. Two (2) labeled USB flash drives with all the information indicated above for items 1, 2, and 3 in PDF format.

1.6 EMS SOFTWARE TOOLS AND LICENSES

- A. The Owner shall be named the license holder of all software products associated with any work on the project. Submit all licensing information for all software installed on the servers and workstations.

- B. Submit a copy of all software installed on the servers and workstations related to this project, for back-up purposes, to the Owner once the project is complete, to include TAB and Commissioning.
- C. All software revisions shall be installed and be current versions thereof at the time of system acceptance.

1.7 PRODUCT HANDLING

- A. Cover and protect material in transit and at site. Material not properly protected and stored, and which is damaged or defaced during construction shall be rejected.
- B. Cover control panels, open ends of control piping and open ends of control valves stored on site until just prior to installation of wiring and valves respectively.
- C. Storage and protection of materials shall be in accordance with specification section 23 05 00.

PART 2 - PRODUCTS

2.1 TEMPERATURE SENSORS

- A. Temperature sensors shall be nickel wire thermistor, 10,000- or 20,000-ohm resistance, or RTD Type, with 1000 ohms resistance at 70 Deg. F. and a 3 ohms/per degree F temperature coefficient. Sensors shall operate in a stable manner in a 5-95% relative humidity, non-condensing environment.
- B. Ambient temperature limits shall be minimum of 0-125 Deg. F. with a +/- 0.5% (+/- 0.35 Deg. F. or +/- 0.20 Deg. C.) accuracy at a nominal resistance equal to 70 Deg. F.
- C. Temperature sensors and cabling used for temperatures below 60 Deg. F. shall be hermetically sealed to prevent condensation damage to conductors or elements. Sensors for immersion locations shall not be affected by vibrations encountered in normal piping systems.
- D. Mixed air temperature sensors shall be the averaging capillary type to sense duct temperature across the full duct width. Minimum sensor length shall be 15 feet and include adequate supports for element within the duct or at the face of the coil, maintain minimum one inch (1") separation from coil.
- E. Furnish sensors with maximum 6-to-9-inch insulated pigtail leads or trim sensor pigtail leads to meet this criteria once installed.
- F. All sensor actions shall be the same for the entire building.
- G. Mount all room wall sensors at 48" inches above finished floor to comply with A.D.A., unless indicated or approved otherwise by the Architect or Owner's Representative.

- H. Wall space temperature sensors for normally occupied spaces shall include the following accessories, features and functions:
 - 1. Temperature Indication (with digital display), Degrees F.
 - 2. Normal Increase/Decrease Temperature Set point adjustments; limits set through software.
 - 3. Impact Resistant Lexan type cover material.
 - 4. Local override pushbutton to energize controlled equipment (override time adjustable through software, initially set at two (2) hours).
 - 5. Local operator interface communication service jack compatible with mobile trouble shooting terminal unit. Alternately, provide spare service jack on terminal equipment controller on controlled terminal equipment.
- I. Wall space temperature sensors in Common Public Areas (Corridors, Lobbies, etc.) shall include the following accessories, features and functions:
 - 1. Temperature display.
 - 2. Temperature adjustment dial or button.
 - 3. Impact Resistant Lexan type cover material.
 - 4. Local operator interface communication service jack compatible with mobile trouble shooting terminal unit. Alternately, provide spare service jack on terminal equipment controller on controlled terminal equipment.
- J. Sensors shall be manufactured by:
 - 1. Reliable Controls.
 - 2. Distech.

2.2 RELATIVE HUMIDITY SENSORS

- A. Provide a 100% solid state copolymer wafer of bonded layer hygrometric materials, humidity sensor and transducer. Sensor shall require no periodic maintenance or recurring calibration. Sensor shall be linear and temperature compensated.
- B. Sensor shall have +/-2% Relative Humidity (RH) accuracy over a 100% RH range and +/-1% over the 30-80% RH range.
- C. Sensor shall produce outputs of 4-20 ma or 1-11 vdc.
- D. Sensor shall be in an impact resistant cover with ventilating openings to allow for room air to circulate through the sensor housing. Provide duct or remote mount probes as required for the application.
- E. Wall mounted sensors shall be mounted 48 inches above finished floor to comply with A.D.A., unless indicated or otherwise approved by the Architect or Owner's Representative.
- F. Wall space relative humidity sensors for normally occupied spaces shall include the following accessories, features and functions:

1. Relative Humidity Indication (with digital display), % R.H.
 2. Normal Increase/Decrease Relative Humidity Set point adjustments; limits set through software.
 3. Impact Resistant Lexan type cover material.
 4. Local override pushbutton to energize controlled equipment (override time adjustable through software, initially set at two (2) hours).
 5. Local operator interface communication service jack compatible with mobile trouble shooting terminal unit. Alternately, provide spare service jack on terminal equipment controller on controlled terminal equipment.
- G. Where relative humidity sensors are shown to be integral with the space temperature sensor include both sensors in the same enclosure.
- H. Acceptable Manufacturers:
1. Reliable Controls.
 2. Distech.

2.3 COMBINATIONS SENSORS

- A. Where two (2) and three sensors, such as temperature, relative humidity or carbon dioxide, are all located in the same location, a combination sensor shall be used.
- B. Submit combination sensors for review and approval.

2.4 AUTOMATIC DAMPERS

- A. Provide all control dampers, under this Section of the Specifications, of the types and sizes indicated on the Drawings, including but not limited to outside air intakes, return, relief, and other motorized air control dampers where shown, or where not an integral part of the equipment furnished and specified in other sections of these specifications. All dampers shall be special low leakage extended performance type.
- B. Damper frames shall be not less than 16 gauge galvanized steel formed for extra strength with mounting holes for flange and enclosed duct mounting.
- C. Dampers shall be available in two-inch size increments from 8" horizontal and vertical to 48". Requirements for dampers over 48" in size shall be met by using standard modules with interconnecting hardware to limit damper blade length to a maximum of 48". Provide separate actuator for damper modules exceeding 32.0 square feet and as required for smaller sizes due to torque requirements.
- D. All damper blades shall be not less than 16-gauge galvanized steel roll formed for high velocity performance. Blades on all dampers must be not over 6" wide.
- E. Blade bearings shall be nylon or oil-ite with 1/2" zinc plated steel shafts.

- F. All blade linkage hardware shall be of corrosion-resistant finish and readily accessible for maintenance after installation.
- G. Provide continuous replaceable neoprene or butyl rubber edging seals for all outdoor and relief air dampers where blade edges meet when dampers are closed. Spring loaded stainless steel side jamb seals shall be provided for all dampers.
- H. Dampers and seals shall be suitable for temperature ranges of -20 degrees F. to 200 degrees F. at specified leakage ratings.
- I. Dampers used for proportional control shall have opposed blades.
- J. Leakage rates for all controlled dampers shall not exceed 5 CFM of air flow per square foot of face area based on a 16 square foot damper, at 1.0" W.C. differential, rated in accordance with AMCA 500. Furnish test data with submittals.
- K. Acceptable manufacturers (No other manufacturers will be allowed): (Use Manufacturers from Distech Spec)
 - 1. Johnson Controls, Inc.
 - 2. Honeywell, Inc.
 - 3. American Warming and Ventilating, Inc.
 - 4. Ruskin.
 - 5. Nailor Industries, Inc.

2.5 ELECTRIC DAMPER ACTUATORS

- A. All control dampers shall be provided with electric actuators to be furnished under this section of specifications.
- B. Electronic direct-coupled actuation devices shall be provided.
- C. Electric Actuators shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a "V" bolt design with associated "V" shaped toothed cradle attaching to the shaft for maximum strength and to eliminate slippage.
- D. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directly mounted to an integral jack shaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or set screw type fasteners are not acceptable.
- E. Actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
- F. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation

are not acceptable. This applies to all dampers directly connected to outside and relief air systems. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

- G. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control input and provide a 2 to 10 VDC or 4 to 20 mA operating range. Where modulating actuators are to be used, or are required, they shall be capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper. Floating point type control is acceptable on controlled fans only. All actuators shall provide for a 2 to 10 VDC position feedback signal although not used at this time. However, software feedback will be used.
- H. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC or more than 8 watts for DC applications. Actuators operating on 120 VAC power shall not require more than 10 VA.
- I. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
- J. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation. Modulating actuators shall be compatible with the PWM output of the direct digital controllers.
- K. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
- L. Actuators shall be Underwriters Laboratories Standard 873 listed.
- M. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a minimum 2-year manufacturer's warranty, starting from the date of Substantial Completion.
- N. All actuators connected to all sequenced dampers shall have independent control and adjustment from one another to emulate a pilot positioner.
- O. Acceptable Manufacturer's:
 - 1. Belimo.
 - 2. Honeywell, Inc.
 - 3. Johnson Controls, Inc.

2.6 SMOKE DETECTORS

- A. One (1) smoke detector shall be furnished and installed under Division 26 for each new air handling equipment item handling over 2,000 CFM of airflow; to be mounted in the return air stream, which shall stop the fan motors upon detection of smoke.
- B. Coordinate with Division 26 requirements to ensure sampling tubes are provided suitable for the width of duct in which it is installed.
- C. Detectors shall be supplied with 120 volts, or 24 volts, power supply under Division 26. Control circuit interlock wiring shall be under this section of specifications.

2.7 CURRENT SENSING STATUS RELAYS

- A. Provide current sensing status relays for motor operation status monitoring as specified elsewhere herein.
- B. Sensors shall be 100% solid state, no mechanical parts, and have no calibration drift.
- C. Sensors shall have an adjustable trip level, be isolated, have single set point adjustment, require no external power (power induced from conductor), and have integrated adjustable wall or floor mounting bracket.
- D. Sensors shall be suitable for motor loads from 0 to 100 HP, with a supply current of 1 ampere up to 135 amperes, 600 VAC RMS, setpoint adjustable to +/-1% range from 0-95% non-condensing relative humidity.
- E. Sensors shall be as manufactured by Veris Industries, Inc.

2.13 TIMER SWITCHES

- F. Furnish timer switches as scheduled or shown on the Drawings and as specified elsewhere herein under Sequence of Operations.
- G. Timers shall be commercial digital timers. Timers shall be adjustable for a minimum of 0-8 hours with no “hold” capabilities, unless otherwise indicated.
- H. Timer switches shall be UL listed and CSA approved.
- I. Timers shall be the suitable for indoor applications and for mounting in a single or multiple gang wall box to allow for recessed mounting in wall.
- J. Each timer shall have a brushed aluminum or stainless steel or impact resistant phenolic cover, or face, plate with phenolic high impact resistant knob(s) or push buttons.
- K. Digital display shall include as a minimum, time interval chosen, time left in that interval and “OFF”. Time interval options shall be in 30 minute increments with units

in minutes and hours. Provide at least four (4) options for time intervals up to a maximum of two (2) total hours.

- L. Label faceplate with identification tags, or plates, as scheduled or specified elsewhere herein, such as “Exhaust Fan EF-1: Toilet”.
- M. Timers shall be suitable for operating conditions from 45 Deg. F. to 120 Deg. F. and be the single pole, single throw, type.
- N. Timers shall be rated (matched) for the load of the circuit it shall control unless relays or other devices allow a lesser rating. Switches shall generally be rated for 1 HP or 20 amps at 125 volts. Provide relays and other accessories as required for a fully functioning system.
- O. Wall timers shall be manufactured by:
 - 1. Lutron.
 - 2. Intermatic.
 - 3. Paragon.
 - 4. Tork.
 - 5. Precision Multiple Controls, Inc.

2.8 LOCAL CONTROL PANELS

- A. New local equipment control panels shall be installed in each equipment room, or other locations as indicated or as required, for new electric control equipment and control devices. They shall be totally enclosed, pre-piped, and wired to labeled terminals to house all associated controllers, thermometers, relays, switches, etc. serving that equipment. Provide one cabinet for each air handling unit or group of units in the same room.
- B. Panels shall be mounted at a convenient height for access. Acceptable locations include mechanical equipment rooms, storage closets, electrical rooms, or other spaces as indicated on the Drawings. Above ceiling locations are not acceptable.
- C. Thermometers, pilot light switches, and gauges shall be flush mounted on panel surface, where applicable.
- D. Cabinet frames shall be extruded aluminum sections with riveted corners supported by internal angle brackets. Door shall have continuous hinged door, with latch and key lock. Alternate hinge arrangements will be considered but details will be required for review and approval thereof.
- E. Sub-Panel and face panel shall be removable for ease of installation and replacement. Face panel shall be of a finished color with a finished frame.

- F. Knockouts for 1/2" x 3/4" EMT connections shall be provided at top and bottom of each panel.
- G. Identify each panel, switch, and device by an engraved, bolt-on, black phenolic nameplate with white lettering securely attached. Identify all control devices inside panels similarly. Embossed plastic tape will not be acceptable on panel front faces but will be allowed on panel interiors.
- H. Switches and pilot lights shall be mounted on the panel face with all other devices mounted inside the panel, as applicable. Devices wired through and inside panels, such as relays, shall be wired to numbered dual terminal strips.
- I. Start-Stop Pushbuttons and Pilot Lights, where called for, shall be of the low voltage and neon type. Pushbuttons shall be heavy duty type. Pilot lights shall be interlocked with starter auxiliary contacts except fans and pumps which shall have current sensing relays to indicate run status.
- J. Each new control panel installed shall have a minimum of 25% consolidated spare/extra space available inside the panel for mounting of control devices for future system modifications or changes. This space shall be indicated on the panel shop drawing.
- K. All wiring inside panels shall be concealed in a wiring harness.
- L. Permanently affix inside each panel a final "as-built" control drawing of the piping and wiring of the panel.
- M. All panels shall be factory assembled, piped and wired and include a key cylinder lock. All locks shall use the same master key.

2.9 ENERGY MANAGEMENT SYSTEM

- A. The central EMS HARDWARE is existing and is located in the City Hall complex. Where new central servers are required, field verify, provide system server as specified elsewhere herein.
- B. Network Automation Engine:
 - 1. Provide a Network Automation Engine (NAE) which shall be a fully user-programmable supervisory controller. Automation Engine shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Automation engines.
 - 2. The NAE shall reside on the automation network. Each NAE shall support one or more sub-networks of a minimum of 100 controllers each.
 - 3. Each NAE shall have the ability to deliver a web based user interface. All computers connected physically or virtually to the automation network shall have access to the web based User Interface (U.I.). Systems without such capability at this level shall provide a user interface via the combination of operator

workstations and web servers as determined by the owner for comparable operation.

4. Processor-controllers shall be multi-tasking, multi-user, and real-time digital control/processors. Standard operating systems shall be employed. Controller size and capacity shall be sufficient to fully meet the requirements of this Section of the Specifications.
 5. Each controller shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
 6. Each NAE controller shall have an integrated Hardware-Based, real time clock.
 7. The NAE shall provide at least one USB port and one URS-232 serial data communication port for the operation of operator I/O devices, such as industry standard computers, modems, and portable operator's terminals. Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
 8. Controllers shall continuously perform self-diagnostics, communication diagnostics, and diagnostics of all panel components. The automation engine shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failures to establish communication.
 9. In the event of the loss of normal power, the NAE shall continue to operate for a user adjustable period of up to 10 minutes, after which, there shall be an orderly shutdown of all the programs to prevent the loss of database or operating system software. Flash memory shall be incorporated for all critical controller configuration data.
 - a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions.
 - b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
 10. All NAE controllers shall be listed by Underwriters Laboratories (U.L.)."
- C. Network Level Controllers shall have a 32 bit based microprocessor with EPROM operating system. DDC programs and data files shall be in non-volatile EEPROM or flash memory to allow simple and reliable additions and changes. Each network controller shall have an on-board 30 day battery back-up real time clock. Controllers shall be provided as required with capacity to accommodate input/output (I/O) points required for the application plus any spare points as specified. Each panel shall be provided with a socket for a Portable Operators Terminal (POT), and a port for network communications at no less than 78,000 baud. Controllers shall have outputs which shall be binary for On-Off control, with true variable voltage (0-10v), for driving analog or pneumatic transducer devices. Analog outputs shall have a minimum incremental resolution of one percent of the operating range of the controlled device. Controllers shall have LEDs for continuous indication of all bus communications,

power, and operational status. All panel electronics and associated equipment shall be installed in suitable enclosures.

- D. Terminal Equipment Controllers (TEC's) shall be UL916 standalone EEPROM based and configured to perform the sequences specified, and with I/O selected for the application. TEC enclosures shall be compact plastic conforming to UL94-5V or plated steel. Each TEC shall be provided with LED type annunciation to continually display its operational mode; power, normal, or in an alarm state. TEC networks operating on a 9000 baud rate shall be grouped with no more than 20 TEC's per primary bus connected device. For TEC networks operating over 50,000 baud, up to 100 TECs may be so grouped.
- E. Furnish and ship damper actuators and terminal unit controllers to the terminal unit manufacturer for factory installation. Refer to Specification Section 23 30 00 and Drawings for coordination details. Terminal unit manufacturer shall furnish transformers, relays, air flow rings, and all metal control enclosures. Under this Section of the Specifications, provide the terminal unit manufacturer with necessary wiring and mounting instructions.
- F. General:
 - 1. Software development and programming shall be as directed by the Owner and as described herein. Contractor shall install all program operating time schedules as furnished by the Owner. During construction, the Contractor may operate equipment in what is considered a Construction Schedule. The control systems installer, at Substantial Completion, shall remove such schedules and replace these with individual, independent, operating schedules for each system and individual piece of equipment, specifically air handling equipment.
 - 2. Program trend logging of all analog and binary points of control at intervals as directed by the Owner, initially use five (5) minutes for all control points.
 - 3. Overall systems control shall be performed by a field programmable direct digital controller, microprocessor based, which incorporates Direct Digital Control, all necessary energy management functions and provides for digital display and convenient local adjustments of desired variations at each individual controller cabinet. This shall include scheduled programming and system interlocks.
 - 4. DDC control units and all hardware shall be capable of continued operation at room temperatures of 40 Deg. F. to 120 Deg. F. and humidity from 10% up to a non-condensing point of 90%. All inputs shall be capable of withstanding continuous shorting to 120 VAC.
 - 5. Provide any external electrical power supply protection devices to protect controllers from external voltage surges to include high voltage and lightning disturbances/protection.
 - 6. Provide function switches in a local control panel, if not integral with the DDC controller, with "on-off" control and a "manual-auto" switch for each new DDC output (contact type) with switch status information being available to the central systems historical data files for all air handling units, fan coil units over 2000 CFM

in capacity, pumps, chillers, controlled exhaust fans over 2000 CFM in capacity, boilers and cooling towers. Alternately, provide this capability integral with the Direct Digital Controllers. Terminal units such as Variable Air Volume boxes, small exhaust fans, small fan coil units, and rooftop A/C units are not required to have function switches. Switches shall be concealed within the local control panel or digital controller enclosure to be lockable. The network manager software shall identify points that are locally overridden and report by display to the building CPU to include generating a printout at the local or remote location printer.

7. Provide a hard wire connection between the Building LAN serving all new controllers to the City EMS workstation. Verify dependable utilization of this system and transfer of local system data and functions to City EMS workstation. General data reporting and alarms transmission shall be verified.
8. Provide a new IBM compatible workstation in the Building as indicated earlier herein. Computer shall be used for digital parameter display, programmed to display analog variables, binary conditions, off normal scans and other analog or binary information required for analysis and adjustment of the system being controlled. Computer shall further contain display features to indicate automatic operation, manual or override operation, alarm indication, and other auxiliary displays associated with special purpose auxiliary function keys.
9. The associated keyboard shall contain all alphanumerical keys to call-up the desired points and type of value to be displayed and have several special dedicated keys for such functions as manual-auto, test and function and value enter, as an aid to the operator. A minimum of two keys shall be programmable for auxiliary functions that may be used frequently.
10. Energy Management System programs shall include, but not all are necessarily utilized, but shall not be limited to:
 - a. Optimal start-stop using an adaptive algorithm to prevent the need for manual adjustments of parameters.
 - b. Optimization programs controlling equipment using outdoor dry bulb and dew point temperatures. The outdoor wet bulb temperature shall be calculated by the following equation:
$$WB = (DB-DP)K+DP \text{ where } K = 0.560-0.0068 (DP-30)$$

G. Control:

1. Control algorithms shall be available and resident in the digital system controller to permit Proportional, Integral, and Derivative control modes in any combination to meet the needs of the application. Other control modes such as incremental, floating, or two-position must be available to adapt to job needs.
2. All control shall be performed in a digital manner using the digital signal from the microprocessor based controller converted through electronic circuitry for modulation of electric actuators.
3. Provide sensitivity adjustment for all DDC output control points.
4. The library of routines available in firmware must be capable of generating additional programs as may be required for specific client tailored requirements. The Owner shall be capable of revising programs without the aide of the installer.

5. Adjustments of all new control variables shall be conveniently available at the computer terminal through the use of the keyboard and display. The adjustments shall include, but not be limited to, proportional gain, integral rate, the velocity and acceleration constants associated with incremental control and on/off values of two-position control.

H. Field Programmable:

1. The local DDC controllers shall each contain all necessary mathematic, logic, utility functions; and all standard energy calculations and control functions in ROM to be available in any combination for field programming the unit. These routines shall include, but not be limited to:
 - a. Math Routines:
 - 1) Basic Arithmetic
 - 2) Binary Logic
 - 3) Relational Logic
 - 4) Fixed Formulas for Psychometric Calculations
 - b. Utility Routines for:
 - 1) Process entry and exit
 - 2) Keyboard functions
 - 3) Variable adjustments and output
 - 4) Alarm Indication
 - 5) Restart
 - c. Control Routines for:
 - 1) Signal compensation
 - 2) Loop control
 - 3) Energy conservation
 - 4) Timed programming
 2. Final field programs shall be stored in battery backed up RAM or in permanent memory.
- I. Expandability: The DDC shall be expandable by adding additional field interface units that operate through the central processor of the DDC. The processor in the DDC shall be able to manage remote field interface units thereby expanding its control loop and energy management point capacity. Remote units shall be able to stand alone and have two-way communication in a LAN configuration. Systems furnished shall be fully manufacturer supported and under current production.
- J. Calibration Compensation: To maintain long term analog accuracy to the controller sensing circuits, the DDC shall sense the voltage being supplied to the resistance

sensing element and through firmware compensate for power supply changes due to long term drift or drift due to ambient temperature changes at the power supply.

- K. Battery Backup shall be made integral in all new DDC system controllers which shall be supplied with a minimum of 48 hours of nickel-cadmium battery backup, during power outages, for the RAM, with an automatic battery charger to maintain charge while power is on, to prevent internal component damage or failure. Alternately provide flash memory instead of battery backup for smaller application specific controllers.
- L. All DDC control modules shall have an automatic restart capability following a power interruption condition which will allow for assigned sequencing of equipment start-up to minimize peak demand upon startup of all energy management system controlled equipment. All EMS controlled equipment with motor loads of one horsepower, or equivalent, and larger, shall be started after power resumes in equal load groups in intervals of every 20 seconds, adjustable, to minimize electrical demand.
- M. Diagnostics: The Digital System Controller shall contain in its program a self-test procedure for checking the digital controllers, and by means of a non-destructive memory, check the computer.
- N. Default Operating Procedure and Alarms:
 - 1. All variables shall be identified as being reliable or unreliable. When a calculation is required to use a value (sensed or calculated), which is identified as being unreliable, the unreliable data value will flash. The calculation will use a default value programmed into the unit.
 - 2. All alarms (a pump that did not start, etc.) and all deviation alarms (temperature, off, normal, etc.) will locally display an alarm as well as report to the CPU the type of alarm, designate equipment or system effected, date and time of alarm. A hard copy printout of alarms shall be generated at the CPU location. A scan can then identify all alarm conditions and their identifier.
- O. Cabinet:
 - 1. The DDC modules shall be enclosed in a metal frame cabinet. The cabinet shall be constructed such that it can be mounted and electrical terminations can be made during the construction phase of the project. The DDC electronics are to be removed and added at a later date, only prior to start-up.
 - 2. Cabinet shall be installed on the wall in the Mechanical Rooms or elsewhere as indicated.
 - 3. DDC cabinets shall be provided with a key lock. All cabinets on each installation shall utilize one master key.
 - 4. All control wiring and system communications shall be electrically terminated inside DDC cabinets.
- P. U. L. Approval: The DDC system panels shall be an approved U.L. System, with U. L. listing as a Signaling System.

- Q. General software features of the CPU and field controllers, with sufficient internal memory, shall include the following as a minimum (although not all are necessarily used):
1. Start-Stop Functions
 2. Optimized Start-Stop Control (warm-up and cool-down)
 3. Time Programmed Commands
 - a. Normal occupancy
 - b. Holiday
 - c. Occupancy overrides
 - d. Schedules shall be programmable up to one year in advance with system wide or global scheduling and local, point by point scheduling.
 4. Duty Cycle Control
 5. Night Setback/Setup
 6. Electric Demand Limiting
 7. Override Feature
 8. Run Time Totalization with data in non-volatile module memory.
Provisions shall be made for on-line programming and override.
- R. On/Off Points of System Control shall be provided for the following (Refer to Drawings for quantity and locations):
1. Split Direct Expansion VRV/VRF Indoor Air Conditioning (A/C) Units
 - a. VRV-1, 2, 3, 4, 6, & 7; all connected to outside air ducts.
 - b. VRV-9 Ceiling Cassette unit connected to an outside air duct.
 - c. VRV-5, 8 & 10; not connected to outside air ducts.
 - d. Remote Outdoor VRV/VRF Condensing Units CU-1A, 1B, 2 & 3.
 - e. All of the VRV/VRF equipment has manufacturer furnished controls which will be integrated with the EMS to allow for monitoring of equipment operation, control points (temperature, relative humidity, alarms, etc.).
- S. Run Status (On/Off) of all units indicated above shall also be provided and shall be capable of being accessed for on-line programming. Status shall be by means of the local motor controller through the use of adjustable current sensing relays, using a current sensing relay on the evaporator fan motor for status on A/C units. Coordinate the means of status with all equipment furnished.
- T. Failure Alarm Status for the following EMS controlled items shall be provided through the EMS:
1. Combined Safety Alarm, one (1) for each A/C Unit and each Condensing Unit.
 2. Dirty filter status for A/C Units, where applicable.
 3. Low/High Temperature Alarms for each temperature sensor installed, four (4) Deg. F. above or below set point, adjustable.

4. High Relative Humidity Alarm for each space relative humidity sensor installed; on a rise above 65% R.H., adjustable.
 5. Needlepoint Bi-Polar Ionizer status and alarm.
 6. Emergency Condensate Overflow Status (suspended A/C equipment located above ceilings - Moisture Detection/High Water Level Alarm via overflow device to be installed at P-trap of each indoor condensate pan): De-energize unit served and send alarm to the EMS. Provide for all indoor A/C Units.
- U. Provide for two annunciation signals for each controlled A/C equipment item, one to indicate that the heating system is operational and one to do the same for the cooling system, to be used for graphic system schematic status.
- V. Provide cumulative run time logging and indication for equipment noted in Paragraph "R", above. Run time logging for all A/C equipment shall be archived for up to 90 days equivalent operation based on 15-minute intervals.
- W. Provide analog indication for the following:
1. For each typical A/C Unit connected to an outside air intake system, provide indication for each of the following:
 - a. Supply air discharge temperature, Deg. F.
 - b. Space temperature, Deg. F.
 - c. Space Relative Humidity, % R.H.
 - d. Space Occupancy for spaces served that are normally occupied, noted as either Occupied or Vacant, as determined by individual dual technology occupancy sensors looped together such that any space that is occupied and served by the A/C unit is operated in the "Occupied" mode of operation.
 - e. Moisture Detection/High Water Level alarm based on condensate overflow conditions for suspended units only.
 2. For Ductless Split Direct Expansion (DX) A/C Units (Without Outside Air Supply):
 - a. Space temperature, Deg. F. (For monitoring and alarm only).
 - b. Supply air temperature, Deg. F. (For monitoring and alarm only).
 - c. Moisture Detection/High Water Level alarm based on condensate overflow conditions for suspended units only.
 3. Provide indication of outside air temperature in Deg. F for this building.
 4. Provide indication of outside are relative humidity in % R.H. for this building.
 5. Damper Position Feedback: On the graphical systems schematics CRT display provide indication of the damper position in % open; 25% open, 50% open, 75% open, etc. Program trend logs for each damper installed.
 6. Emergency Power Generator: Status (when operated), Run Time, and Fault conditions as they occur (malfunction or safety trip of some type).
- X. Building Computer Software Management features

1. Provide minimum of 15 User Selectable Passwords with a minimum of three levels of access. Highest level provides system access, secondary level provides access for command to field devices only, lowest level provides monitoring capabilities only with no field control allowed. Password access will be logged with time/date stamp and associated user ID.
2. Provide a minimum of 16 Point Group Summaries with each point inclusion selectable by system operator. Summaries will have a minimum of six (6) character identifiers for each group. A separately selectable All Points Summary shall be available to the operator for a view of the complete system. Alarm Summaries, listing all points in an alarm status shall be provided, and shall be Owner definable.
3. Trend logs and summaries:
 - a. The Central Computer Workstation (CPU), shall be provided with, as a part of this contract, the ability to periodically trend any hardware, software, or simulated point within any of the attached DDC panels, for this project, at an Owner selectable interval of a minimum of once per second, up to at least once per 1000 minutes.
 - b. The trending programming for selected points and all feature attributes of these points shall be accomplished online at the CPU with no disruption of dynamic communication with the remote DDC panels. The operator shall be able to add, delete, and modify points and attributes at any time while online. Online programmable attributes shall include:
 - 1) Point addition, deletion, and modification
 - 2) Sampling intervals and ranges
 - 3) Historical samples to be stored per individual point
 - 4) Dynamic data values
 - 5) Engineering units of each point
4. Online editing capabilities shall be provided for, but not limited to the following:
 - a. Add/Delete Points
 - b. Modify Engineering Units
 - c. Modify/Create Point Groups
 - d. Adjust Set Points
 - e. Adjust Individual Start/Stop Times
 - f. Trend Selected Points
 - g. Observe Any System Point, Hardware, or Software
 - h. This editing capability shall be for both CPU resident programs and remote DDC panel programs.
5. English language shall be used for all inputs, outputs, and display. Code or computer language will not be acceptable.
6. Remote DDC Field Communication: Communication between the Central Computer Workstation and the remote DDC panels shall be achieved via digital transmission utilizing a distributed polling technique for recognition of all field

points, both software and hardware points status, issuing of commands, programming of DDC units, etc. Additionally, provide software for the existing City EMS workstation to allow the same interaction/communication features as noted for the Building Workstation. Data transmission shall be via hardware connection compatible with electric category Type 3002, as described in Bell System Technical Publications for Data Transmission using the highest Baud Rate reasonably possible.

7. Computer Screen Format:

- a. The Computer Screen format shall include a display in an individually dedicated and protected area of the viewing screen the following Dynamic information:
 - 1) The current time, date, and day of week (including Holidays).
 - 2) Sequential, as occurred, alarms.
 - 3) Visual indication of alarm or off normal conditions which are active.
 - 4) Current operator identification.
 - 5) Operator work area to display various forms of point information issue commands, and data base information relevant to current activities.
- b. Operator will have full access to the system for issuing commands, etc. while this display is active.

8. Provide a graphic software package and programming to result in a schematic illustration for each controlled piece or group of pieces, of equipment to illustrate all related controlled variables, set points and operating parameters.
9. Provide a building floor plan with room numbers and locations of all space sensors and controlled equipment. The user shall be able to click on any feature to pull up related system graphics.

2.10 DATA SERVERS, WEB SERVERS, DDC SYSTEM SERVERS AND WORKSTATIONS

A. Hardware Requirements:

1. The following minimum requirements apply to system servers, data server, web server and operator workstations:
 - a. 3 GHz Clock Speed Pentium 4 processor with 1 GB of RAM.
 - b. Serial port, parallel port and 4 USB ports.
 - c. 10/100 MBS Ethernet NIC.
 - d. 500 GB minimum Hard Disk.
 - e. DVD-RW drive (minimum 56X) CD ROM.
 - f. High resolution (minimum 1280 by 1024), 17 inch flat panel display.
 - g. Optical mouse and full function keyboard.
 - h. Audio sound card and compatible speakers.

B. Software requirements:

1. General: The following software with license agreements shall be provided.
 - a. System Servers:
 - 1) Microsoft Windows Server.
 - 2) Microsoft Office Professional Edition, latest edition.
 - 3) DDC System Server Application, latest revision.
 - 4) Any other software required to deliver the specified performance.
 - b. Data Servers:
 - 1) Microsoft Windows Server Operating System, current edition.
 - 2) Microsoft Sequel, latest edition (It is important that your data server be equipped with what is referred to as “Full Sequel” and not one of the reduced capacity versions such as “Microsoft Sequel Desktop Engine (MSDE)”. Data collection and analysis is an important feature of DDC systems, and reducing your ability to collect and store long term data is not worth the small savings achieved by the purchase of a reduced capability software package.)
 - 3) Microsoft Office Professional Edition, latest edition.
 - c. Web Server:
 - 1) Microsoft Windows Server Operating System, current edition.
 - 2) Microsoft Office Professional Edition, latest edition.
 - 3) DDC System Web Server Application, latest revision.
 - 4) Any other software required to deliver the specified performance.
 - d. Operator Workstations:
 - 1) The latest Microsoft Windows Operating System, current edition.
 - 2) Microsoft Office Professional Edition, latest edition.
 - 3) DDC System Operator Workstation Application(s), latest revision.
 - 4) Any other software required to deliver the specified performance.

C. Portable Operating Terminals (POT)

1. Minimum Hardware Requirements:
 - a. Laptop Computer.
 - b. 3GHz Pentium 4 processor with 1GB of RAM.
 - c. Serial port, parallel port and 4 USB ports.
 - d. 2 PCMCIA Slots.
 - e. 10/100 MBS Ethernet network interface.
 - f. 40GB Hard Disk
 - g. CD-RW Drive.
 - h. Touchpad mouse functionality.
2. Software Requirements: The software requirements for a POT are identical to those for an operator workstation.
3. Graphic Pages:

- a. Hierarchy:
 - 1) The organization of graphic pages shall be from a global level down to a very detailed level through a series of links.
 - 2) Linking shall allow the operator to move down the hierarchy, up the hierarchy and laterally within the hierarchy.
- b. Hierarchy Outline:
 - 1) Site Plan Page: A visual representation of the site (map). One page or multiple linked pages depending on the size of the site plan.
 - a) Link to individual building graphic pages.
 - b) Display outdoor weather conditions.
 - 2) Utility Management Page: A summary of data on the utility consumption for the site.
 - a) Link up to the site plan.
 - b) Display:
 - (1) Utility consumption data.
 - (2) Demand data.
 - (3) Voltages, currents and power factors.
 - (4) Demand control actions currently in effect.
 - c) Presenting the utility management data may require more than one graphic page to effectively report the data from multiple meters.
 - 3) Building Graphic Page: Typically a picture of the building. One page per building.
 - a) Link to floor plans within building.
 - b) Link to central plant graphics where the plant serves the entire building.
 - c) Link to delivery systems if the delivery system serves the entire building.
 - d) Link up to the site plan.
 - 4) Floor Plan Page: This will be a two dimensional plan of a floor area. A minimum of one page per floor per building is required. Where floor plans are large, multiple linked pages are required. For each control zone the value of the controlled parameters shall be displayed. This will typically be lighting status, temperature and relative humidity if relative humidity is a controlled variable.
 - a) Link up to the Building page.
 - b) Link up to the Site Plan page.
 - c) Link to any delivery system that serves the floor plan area (air handling unit is typical).
 - d) Link to time schedule that affect the systems that serve the area.

- e) Link to Terminal Unit Summary page where multiple zones on the floor are served by unitary control devices.
 - f) Individual control zones shall be identified.
 - g) The location of terminal equipment serving each zone shall be shown.
 - h) The location of sensors installed in the occupied space shall be shown.
 - i) Where room numbers are available, they shall be shown. Revise room numbers in graphics to match the actual room numbers selected and installed in the facility; if not matched to construction drawing room numbers.
- 5) Delivery System Page: A graphical representation of an air delivery system such as a D/X air handling unit, 100% outside air unit. One page for each delivery system.
- a) If the Delivery System serves a specific floor area, link up to the Floor Area page.
 - b) Link up to the Building page.
 - c) Link up to the Site Plan page.
 - d) If the Delivery System supplies multiple terminal devices, link to a Terminal Unit Summary page.
 - e) Link to a Delivery System Configuration page.
 - f) The graphical representation of the equipment shall be 3-dimensional and represent the true physical characteristics of the installed system.
 - g) Display:
 - (1) Process variables.
 - (2) Commands to end devices.
 - (3) Status of end devices.
 - (4) Status of different modes (economizer on/off, mechanical cooling enabled/disabled, occupied/unoccupied).
 - (5) Alarm points.
 - h) Link to any time schedules that affect the system operation.
 - i) Link to any pre-configured trend charts for the system.
- 6) Delivery System Configuration Page: On this page the operator is given access to the configuration parameters for the delivery system. Typically, this page presents data in a tabular format. The type of data on this page is not changed frequently, but the operator may wish to view it frequently. One page per delivery system is required.
- a) Display.
 - (1) Set Points.
 - (2) Turning Parameters.

- (3) Calibration Parameters.
- (4) Timing Parameters.
- (5) Application Parameters.
- (6) Reset Schedules
- (7) Lead Lag Information.
- (8) Time Schedules.
- b) Link up to the Delivery System page.
- c) Link up to the Building page.
- d) Link up to the Site Plan page.
- 7) Terminal Equipment Summary Page: On this page the dynamic data and set points that are associated with multiple terminal units are presented in a tabular format. The objective is to present a summary of terminal unit performance for an area of the facility. One page is required for each group of terminal units. In the tabular data, do not use less than 12 pt. font size. Multiple linked pages may be used if there are a large number of terminals served by one delivery system.
 - a) Display in the table:
 - (1) Process variables.
 - (2) Set points for each process.
 - (3) Command to each end device.
 - (4) Status of each end device.
 - b) Link to the page for each Terminal Unit.
 - c) Link up to the Delivery System page.
 - d) Link up to the Floor Plan page.
 - e) Link up to the Building page.
 - f) Link up to the Site Plan page.
- 8) Terminal Unit Page: A graphical representation of a terminal unit such as a D A/C unit and 100% outside air unit. One page for each terminal unit.
 - a) Link up to the Terminal Summary page.
 - b) Link up to the Floor Plan page.
 - c) Link up to the Building page.
 - d) Link up to the Site Plan page.
 - e) The graphic representation of the equipment shall be 3-dimensional and shall represent the actual installed terminal unit.
 - f) Display:
 - (1) Process variables.
 - (2) Command to end devices.
 - (3) Status of end devices.
 - (4) Set points for each process.
 - (5) Modes (auto, heat, cool, etc.).

- (6) Capacity indicators (terminal load, % heat, % cool, etc.).
 - (7) Reset schedules.
 - (8) Occupancy commands and status.
 - (9) Alarm points.
 - c. For all points on a graphic page that are subject to being under manual or test mode, the display shall indicate when test mode or manual mode has been applied to the point.
 - d. Graphic Page Requirements:
 - 1) The sequence of control defines the buildings and all of the equipment items for which graphic pages shall be constructed as described above.
 - 2) The Contractor shall develop similar additional graphic pages to be defined during the construction period as follows:
 - a) Up to five additional pages per building.
 - b) Up to twenty additional global pages.
- 4. User Groups:
 - a. The Contractor shall configure four user groups, one for each level of security. The group names shall be representative of the “names” below:
 - 1) Administrators.
 - 2) Engineers.
 - 3) Operators.
 - 4) Viewers.
- 5. Users:
 - a. The Contractor shall configure two users in each group. The name and passwords shall be representative of the “names” below:
 - 1) Administrators Group:
 - a) Admin1 / Admin1
 - b) Admin2 / Admin2
 - 2) Engineers Group:
 - a) Engr1 / Engr1
 - b) Engr2 / Engr2
 - 3) Operators Group
 - a) Oper1 / Oper1
 - b) Oper2 / Oper2
 - 4) Viewers Group
 - a) View1 / View1
 - b) View2 / View2
 - b. With the exception of the Viewers Group, these users shall not be added to the system until all testing has been completed and the system has been accepted. The Contractor shall accept all responsibility for actions the result from the unauthorized issuance of user names and passwords above the level of viewers

prior to system acceptance unless specifically instructed to do so in writing by the Owner.

6. Alarm Processing:

- a. All alarms required by the sequence of control shall be fully configured for delivery to the operator workstations and the alarm files.
- b. A common alarm file shall be established to receive alarms from all of the field devices.
- c. A separate alarm file shall be established on a per building basis to receive just the alarms from that building.
- d. The alarm messages shall be descriptive and include as a minimum:
 - 1) System identification.
 - 2) Date.
 - 3) Time to the second.
 - 4) Nature of the alarm such as high value, low value, or fail to start.
- e. The system shall be configured to send an alarm message on return to normal.
- f. All users shall receive all alarms.

7. Reports:

- a. Each item of equipment sequence of operation includes various control points, inputs, outputs and parameters to be monitored such as temperature, pressure, relative humidity, carbon dioxide levels, etc. It is a requirement of this section of specifications to trend each of these variables. The data server shall be setup to collect all of this data for up to a 90 day period with all variables noted herein set up initially for 15 minute trend intervals. System operators shall have the ability to look at the historical trend data on a trend log basis or in a graphical format as needed. It is very beneficial to the owner for performance assessment, troubleshooting operational issues or for energy management purposes to have a set of standard reports that analyzes the data and puts it in a format to drive management decisions. Typical examples are:
 - 1) Run time reports on equipment.
 - 2) Performance deviation reports that compare actual performance with specified performance. An example would be the average deviation from set point for space temperature, discharge air temperatures on air handling units, etc.
 - 3) Equipment efficiency reports such as measurements of kW per TON for a chiller over time.
- b. In this section of the specifications, a description of the reports to be prepared should be described. The control systems installer is best qualified to set these reports up during construction rather than leave this responsibility to the owner after acceptance. As such, sample trends shall be provided to the Owner and Engineer at the time of project close out.

D. Data Server:

1. Contractor shall configure the data server to receive historical trend log data for the trend logs specified in the sequence of control.
2. Written instructions on the archiving process and retrieval of archived data shall be prepared and left with the data server.
3. WEB Server:
 - a. The web server shall be configured to present data from all of the field devices.
 - b. The web server shall be configured to allow 5 concurrent users.
 - c. The web server shall be configured to require a user name and password for log-in from a web client.
 - d. The web server shall be configured to allow the web clients to do the following:
 - 1) View all graphic pages that can be viewed from a operator workstation.
 - 2) View historical trend logs.
 - 3) Receive and acknowledge alarms.
 - 4) Manually control points.
 - 5) Initiate generation and view static reports.
 - 6) Adjust time schedule parameters.

2.11 WEB BROWSER INTERFACE

A. Provide Internet connectivity utilizing a Web Browser as follows:

1. Shall be a “Server” based product that provides browser access to Ethernet enabled automation controllers. Access is accomplished by utilizing Microsoft Internet Explorer 11.0 or later. No other “client” side software shall be necessary to view and utilize the system. The “Server” hosting the Web Application can be located anywhere on the Internet. The software functions by taking real-time data from the active automation systems and combining that information with the appropriate graphic file in an HTML format to be viewed by the web browser. The number of simultaneous users connected to the web application shall only be limited by the capability of the server hosting the application. The application should be able to service multiple sites.
2. The graphics utilized for this system shall not require external applications to convert the images for use between the web server based application and the traditional graphical user interface. Graphics shall be interchangeable between applications.
3. Web Browser Server shall receive server-based software which shall support Microsoft’s .NET standards for the exchange and interoperability of information and data.
4. All Central Server software based upgrades shall be free to the owner for the first year the server is owned by the building Owner.

B. The Host Server shall be reused and includes the following requirements for IIS based applications as a minimum:

1. Intel Pentium III 1.2 GHZ Processor.
2. Gigabyte Dual Socket 370 Server Motherboard.
3. 2x Maxtor 40 GB, 7200 RPM ATA/133 Hard Drive.
4. 1.44 MB Floppy Drive, LG 52X CDROM Drive.
5. 512MB SDRAM.
6. Current version of Windows Service License, IIS Service.
7. Monitor, Keyboard, Mouse.
8. Case to house above components shall be capable of being rack mountable, optional per actual site requirements.

C. The Web Browser Interface shall include the following user configuration requirements:

1. Usernames and passwords can be setup via the Web Browser Interface. Physical access to the server is not required but will be password protected.
 - a. Individual user names/passwords are to be utilized.
 - b. Usernames/passwords can be specifically unique to allow the user to be automatically redirected to a specific site, and or graphic display when logging into the system.
2. Passwords can be configured to allow the user to modify setpoints or not.
3. All user configuration functions shall be provided through an intuitive graphical user interface.
4. Web Browser Interface shall not require any external applications, "Client Side" software or "Plug-Ins" to connect, view, or control any aspect of the building automation system.
5. Access to the installed automation system shall be performed through Microsoft Internet Explorer.

D. Site Graphics shall meet the following requirements:

1. Graphics displayed through the Web Browser Interface must be the same graphic images provided through the Graphical User Interface described above. No external applications are to be required to interchange graphic images between the web server application and the graphical user interface.
2. Trend data must be able to be displayed graphically and in "spread sheet" format without the addition of any additional client side software, plug-Ins, or additional applications.
3. Digital Start/Stop Logging shall be able to be displayed and printed from the browser interface without the addition of any additional "client side" software, plug-Ins, or additional applications.
4. The display and printing of alarm data shall be performed without the addition of any "client side" software, plug-Ins, or additional applications.

5. Points that are manually overridden shall be displayed on the graphic screen by an icon adjacent to the overridden point to provide a quick visual indication of any points on the screen that are overridden.
6. The viewing and modification of weekly schedules shall be performed in a graphically intuitive manner that is consistent with the non-Web Enabled application. This shall be performed without the addition of any “client side” software, plug-Ins, or additional applications.
7. The viewing and modification of annual holiday schedules shall be performed in a graphically intuitive manner that is consistent with the non-Web Enabled application. This shall be performed without the addition of any “client side” software, plug-Ins, or additional applications.
8. “Right clicking” on the point and modifying the value shall perform the editing of point values.
9. Points can be placed in “manual” or “automatic” mode from the Web Browser, providing password restrictions for the user allow such functionality.”

2.12 ELECTRICAL WIRING

- A. All wire, wiring, and conduit required for the operation of the control system shall be the responsibility of this section of the specifications and shall be installed as described and in full accordance with the requirements of Division 26 of these Specifications.
- B. The control manufacturer shall be responsible for supplying complete and approved wiring diagrams and installation supervision of the wiring of the control system and shall perform all necessary set-up and calibration labor.
- C. Starters, furnished in other sections of these specifications, shall be installed under Division 26, but all wiring from auxiliary contacts or relays shall be under this section of the specifications.
- D. All wiring, including Class 2 signal wiring, shall be installed as a Class 1 electrical system as defined by the National Electrical Code (NEC).
- E. All control conduits with #8 conductor or smaller (cross-sectional area) shall have one pull wire each run in conduits carrying 5 or more conductors. Conduits with 9 or more conductors shall have two pull wires installed. Terminate pull wires at control panels in an acceptable manner and tag wires as “future”.
- F. The electrician shall be licensed by the City and local authorities having jurisdiction over the area in which the work is to be performed.
- G. All class 1 control wiring conduit shall be run with not more than 30% fill based on inside conduit diameters and cross-sectional area. This provision is for future modifications or additions to the control system.
- H. All conduit carrying shielded twisted pair cabling, communication, or signal, Class 2 wiring, shall be sized for a maximum of 40% fill based on inside conduit diameter and

cross-sectional area. This provision is for future modifications or additions to the control system.

- I. All wiring shall be run in conduit unless specifically indicated otherwise herein. All Class 1 power wiring shall be run in conduit. All Class 2 signal wiring, low voltage control type, shall be run in conduit. No exposed wiring of any kind will be allowed. However, Class 2 signal wiring may be installed without conduit above accessible lay-in ceilings only if run-in plenum rated cable, supported independently from structure, and run parallel and perpendicular to the structure.
- J. All conduit shall be 3/4 inch size minimum, except raceways terminating at control devices manufactured with 1/2" knock-outs, i.e., conduit from junction box to smoke or fire detectors (local single device wiring only).
- K. Electrical Systems Installer on project may perform temperature control conduit and wiring installation on project only that this portion of work shall be bid directly to the Temperature Control Systems Installer, and all work in relation to temperature control wiring shall be done subordinate to this Section of the Specifications. All control wiring terminations shall be made under this Section of the specifications.
- L. Under this Section of Specifications, furnish and install, at an early stage of construction (when walls are being constructed) galvanized steel back boxes for all wall mount space sensors, suitably secured with 3/4" EMT routed to four inches (4") above an accessible ceiling. Install with pull wire for installation of sensors and related wiring at a later stage of construction.
- M. Work Not Included Under this Section of Specifications: The Electrical Systems Installer shall provide:
 - 1. Branch circuit and motor feeder circuit conductors, raceway, connections, and overcurrent protection for each motor or item of equipment furnished by the Owner or other Contractors.
 - 2. Installation of motor controllers furnished by the Owner or other Contractors, along with branch circuit and motor feeder circuit conductors, raceway, and connections in accordance with the manufacturer's approved wiring diagrams.
 - 3. Disconnect switches, where indicated on the drawings or required by codes, except as provided as an integral part of manufactured equipment.
 - 4. Power supply conductors, raceway, connections, and over-current protection for input power to HVAC Temperature Controls, HVAC Automation, HVAC Energy Management Systems and combination fire-smoke and smoke dampers in accordance with approved rough-in and connection diagrams furnished by the system suppliers only when shown on Division 26 Drawings.
 - 5. The above represents an outline of the work for the purpose of describing one division of the work which is acceptable to insure that all work is contained within the General Contract. The Contractor is fully responsible for the installation of

- complete, operating systems in accordance with the functional intent of the specifications.
6. Nothing herein shall be construed to confine the Contractor from assigning the work to any single member or group of systems installers deemed best suited for executing the work to effect completion of the contract. Refer to specific bidding instructions of the General Contract for the actual division of the work.
- N. Work Included Under other Sections of Division 23 of the Specifications: The Mechanical Systems Installer shall provide:
1. Motors and equipment, erected in place and ready for final connection of power supply wiring, along with manufacturer's approved wiring diagrams.
 2. Motor controllers, in suitable enclosures and of the type and size in accordance with the manufacturer's recommendations and NEMA requirements, along with properly sized overload elements or devices which are normally provided as part of manufactured equipment.
 3. Disconnecting switches or devices which are normally provided as a part of manufactured equipment.
 4. Rough-in and connection diagrams for input power supply and connections for the HVAC Temperature Control, HVAC Automation, and HVAC Energy Management Systems.
 5. The above represents an outline of the work for the purpose of describing one division of the work which is acceptable to ensure that all work is contained within the General Contract. The Contractor is fully responsible for the installation of complete, operating systems in accordance with the functional intent of the specifications.
- O. Contractor, under this Section of the Specifications, shall insure the furnishing and installation of:
1. All new branch circuit wiring, conduits, protective devices and accessories for power supply wiring to serve new control panels, control transformers, electric control dampers and valve actuators, and any other control system power requirements where not shown to be performed by others. Field verify spare electrical circuits available where applicable. Do not tap into existing branch circuits without approval by the Owners Representative. Run all new circuits back to electrical feeder panels.
 2. Conductors and raceways for the HVAC temperature control, HVAC automation, and HVAC Energy Management System in accordance with approved rough-in and connection diagrams furnished by the system suppliers.
 3. Termination of all conductors, raceways, devices, and connections for low voltage systems for the HVAC Temperature Control, HVAC Automation, and HVAC Energy Management Systems in accordance with the provisions of Division 26, and approved systems shop drawings to provide complete operating systems in accordance with the functional requirements of the specifications.
- P. Wire all safety devices in series to include freeze-stats, fire-stats, and smoke detectors; any single device when tripped, shall de-energize air handling equipment.

Q. Wiring Requirements shall also include the following:

1. The conduit/wiring system required for the Automatic Temperature Control (ATC)/Energy Management System shall be a complete, separate, independent system. Conduit sharing with other unrelated electrical systems is not permitted.
2. All wiring shall be labeled at both ends and at any spliced joint in between. Wire and tubing shall be tagged using 3M, Scotch Code Write On Wire Marker Tape Identification System; product number SWD-R-11954 with 3/4" x 5/16" write-on area or SLW 12177 with 1" x 3/4" write-on area and with 3M Scotch Code SMP Marking Pen. In addition to tagging at field device end and at spliced joints, a tag shall be placed 6" after entering each DDC panel. Identification and tag information shall be included in engineering/wiring submittal which must be submitted for Owner approval prior to beginning work. Tag information shall coincide with equipment/point information as written in the specification Input/Output summary.
3. Digital Input (D.I.) wiring (Class 2) may be run in a common conduit with Digital Output (D.O.) Wiring (Class 1) where local codes permit.
4. Analog Input (A.I.), Analog Output (A.O.), Digital Input (D.I.), and Network Communications Trunk (N.C.T.) wiring may be run in a common conduit.
5. Digital Output (D.O.) wiring run in a common conduit with Analog Input (A.I.), Analog Output (A.O.), or Network Communication Trunk (N.C.T.) is not permitted under any circumstances.
6. AC line power to DDC panel shall be #12 THHN.
7. Digital Output (D.O.) wiring shall be #14 THHN.
8. Digital Input (D.I.), Analog Input 4-20 mA (A.I.) and Analog Output (A.O.) wiring shall be #18 TSP (twisted shielded stranded pair with drain wire).
9. Analog Input or voltage types (A.I.) wiring shall be #18 TSP (twisted shielded stranded pair with drain wire).

2.13 GENERAL

- A. System shall be installed complete with DDC panels, remote panels, thermostats, sensors, control dampers, all actuators, switches, relays, alarms, etc., and control conduit in accordance with the extent of the sequences of operation. Provide all auxiliary equipment required. All controls shall be installed under this section of work, with the exception of automatic dampers which shall be furnished under specification section 23 30 00.
- B. Control Systems manufacturer shall submit a complete and final check list verifying final calibration and set points for each system prior to final construction review.
- C. Complete control drawings shall be submitted for approval before field installation is started. The submittals shall give a complete description of all control devices and show schematic piping and wiring, as well as a written sequence for each operation.
- D. All control dampers shall be furnished by Control manufacturer and shall be set in place, under other sections of the specifications, and be adjusted for proper operation,

including the installation of necessary linkages with actuators under this section of specifications. Contractor shall also furnish, under other sections of the specifications, install any necessary blank-off plates required to fill duct when damper size is smaller than the duct. All outside air damper frames and blank-off plates shall be caulked air tight with non-hardening silicone caulking to the ductwork or frame opening.

- E. Work under this section shall regulate and adjust the control system, including all controllers, thermostats, relays, control dampers, motors, and other equipment provided under this contract. They shall be placed in complete operating condition subject to the approval of the TAB firm. Contractor shall cooperate fully with the balancing agency in the testing, check-out and adjustment of the various systems. Contractor, under other sections of these specifications, shall install all automatic dampers.
- F. Control system herein specified shall be free from defects in workmanship and material under normal use and service. If, within twelve (12) months from the date of "Substantial Completion", any of the equipment herein described is proven to be defective in workmanship or material (except electrical wiring done by others), it shall be adjusted, repaired, or replaced free of charge.

PART 3 - EXECUTION

3.1 SEQUENCE OF OPERATION – INDOOR A/C UNITS (SERVED BY OUTSIDE AIR); VRV-1, 2, 3, 4, 6, 7 & 9 (VRV-9 IS A CASSETTE TYPE UNIT)

- A. Furnish and install new combination space temperature and relative humidity sensors for each new A/C unit designated above which shall heat, cool and indirectly dehumidify the spaces served as well as deliver conditioned outside air to the spaces served only when occupied, under this Section of Specifications.
- B. Space sensors, through a dedicated A/C unit manufacturer controller, shall independently control each A/C unit as specified herein. Fully coordinate this scope of work with that manufacturer to ensure a complete and operational system.
- C. The control system shall also be integrated with wall or ceiling mounted space occupancy (dual technology) sensors, provided and installed under Division 26.
- D. Control system for each unit shall control the DX Cooling-Heating Coil, typically one or two-stage, as applicable, and internal unit fan speed control used for indirect dehumidification system control.
- E. Provide the following sequence of operation:
 - 1. Each space temperature sensor shall be of the automatic change-over type to provide for a heating and a cooling set point to be interlocked, by electronics, to prevent the cooling set point from being set below the heating set point and vice-

- versa. Provide a minimum 2 Deg. F., adjustable, dead band between these set points.
2. Include an optimized start and stop feature, to warm-up or cool-down the spaces served, for unit control where the space temperature is compared to the ambient outdoor air temperature (where able to be integrated into this system) to calculate the minimum run time necessary to attain the normal mode set point by the occupied time scheduled. Currently this feature is not planned to be used.
 3. Evaporator fan shall cycle on and off, to heat or cool, as required, in any unoccupied mode of operation as determined by looped occupancy sensors, located only in normally occupied spaces, which shall detect the presence or lack of presence of people. During no occupancy of the spaces served, tightly close the respective outside air dampers.
 4. When each unit is started, the normally closed motorized outside air dampers shall be closed. These dampers shall open to the design position scheduled only after a two (2) minute, adjustable, time delay when energized for a normal building occupied mode as determined by looped occupancy sensors. When each unit is turned-off, the dampers shall fully close. Outside air dampers shall remain closed during any unoccupied mode.
 5. Upon a need for mechanical cooling, the DX cooling system shall maintain a space temperature set point of 71 Deg. F (adj.). On a rise above set point the 1st stage of cooling, as applicable, shall be energized, if not already energized to serve other VRVs served by the same CU. For 2 stage units the second compressor stage will only be energized upon a further rise in temperature above set point and when the first stage compressor has been on longer than five (5) minutes, adjustable. On a decrease in demand for cooling the second stage compressor shall be cycled off. On a further decrease in space temperature, the first stage compressor shall be cycled off to include the evaporator fan. The evaporator fan shall run continuously in the occupied mode and only when occupancy occurs in the spaces served as confirmed by the looped space occupancy sensors. All set points shall be fully adjustable.
 6. Evaporator fans shall run continuously in the occupied mode only, unless the single occupancy sensor, or group of sensors, as applicable, detects no people present in the areas served in which case the fan shall then cycle off and the outside air dampers shall be closed. While a unit is programmed to be in the occupied schedule, with no occupancy sensed, the unit shall cycle on and off only as needed to maintain the normal heating or cooling set points (with outside air dampers closed).
 7. The heating temperature set point shall be 69 Deg. F., adjustable. All set points shall be fully adjustable. On a drop in space temperature below set point, the heat shall be cycled on as required to maintain set point and to meet demand in a stable fashion.
 8. The outdoor condensing unit shall be operated anytime any indoor unit connected thereto has a demand for heating or cooling. The overall unit shall be in either the heating mode or cooling mode but not simultaneously.

F. Space temperature sensors will also be used to operate the units in the unoccupied modes of operation. Night set-back set point is normally set at 55 Deg. F. to energize

the unit to heat and to turn off the heat at 60 Deg. F. Night set-up set point is normally set to turn on the unit to cool at 84 Deg. F. and turn off the cooling at 80 Deg. F. Since many spaces in Fire Stations generally operate 24 hours a day, each A/C unit shall have controlled set back and set up set points of 67 degrees F for night set-back (off at 69 degrees F.) and 73-degrees F. for night set-up Off at 71 degrees F.), respectively, all set points adjustable.

- G. Dehumidification mode begins when the room temperature sensor cooling demand has been satisfied but the space relative humidity rises above 50% R.H. The manufacturer's control system shall send a signal to the respective unit to reduce fan speed while operating at minimum cooling capacity under these conditions (assuming the spaces are occupied per the occupancy sensor status). Should the space begin to be overcooled, then cooling will stop until the space temperature rises to 1 degrees F. above cooling set point, after which this mode can repeat. Lock out operation of the dehumidification mode when the outdoor air temperature exceeds 95 Deg. F., adjustable.
- H. Provide wall or ceiling mounted occupancy sensors, refer to Division 26 drawings, to control A/C unit evaporator fans and outside air dampers as noted herein and as shown on the drawings. The occupancy sensor(s) served by a respective A/C unit shall be looped together such that they, as a group, control the respective A/C unit outside air dampers and supply air fan serving the spaces on the same loop. Provide combination (infra-red and ultra-sonic) wall mounted occupancy sensors, to be looped together to determine "occupancy" for control of the following spaces for each unit listed:
 - 1. VRV-1: Community Room, Plan Room 132.
 - 2. VRV-2: Watch Room, Plan Room 103.
 - 3. VRV-3: Day Room, Plan Room 104.
 - 4. VRV-4: Kitchen, Plan Room 105.
 - 5. VRV-6: Dorm Rooms & Officer Office, Plan Rooms 110, 111, 113 & 107.
 - 6. VRV-7: Dorm Rooms, Plan Rooms 125, 126, 127 & 128.
 - 7. VRV-9: Fitness, Plan Room 200
- I. Occupancy sensors shall perform two functions:
 - 1. Any occupancy, when occupancy is sensed, shall cause the respective evaporator fan to run continuously. When no occupancy is sensed by all sensors on the same loop, the fan shall be turned off, and the unit shall only cycle on and off as needed to maintain the unoccupied set points.
 - 2. When all occupancy sensors on a common loop determine the areas served by a unit are not occupied, close the outside dampers until occupancy is sensed again.
 - 3. All occupancy sensors shall provide for full coverage of each space served, be wall or ceiling mounted as shown on Division 26 drawings, be infrared and ultrasonic (dual technology) based, and be submitted for approval, to include products, shop drawings and wiring diagrams.

- J. Provide one (1) outside air temperature and one (1) outside air relative humidity sensor in a shielded outside air enclosure (to be located in a fully shaded location; north side eave area) to be used for global control applications and monitoring purposes.
- K. Each space sensor assembly shall have an integral override button and feature that may be used to energize the respective A/C unit served should it be commanded off to allow the unit to operate for a period of two (2) hours, adjustable (0-8 hours minimum).
- L. Provide a float switch in the auxiliary drain or overflow pipe connection for all A/C units installed which shall cause the respective A/C unit served to be de-energized upon detection of water in the pan (float raised) and send a signal to the EMS to alarm facilities staff of this condition.
- M. All split DX units are served by emergency power.

3.2 SEQUENCE OF OPERATION - EXHAUST AIR FANS

- A. Provide and install new wall mounted timer switches, as specified elsewhere herein, to control non-critical intermittently controlled exhaust fans where shown on the electrical drawings. Coordinate installation of timers furnished under this section of specifications, to be installed under Division 26. Timer switches shall include multiple time “on” selections, to be user selected.
- B. It is intended to provide up to 3-4 time selection options per fan, user selected.

3.3 SEQUENCE OF OPERATION – MINI-SPLIT DUCTLESS DIRECT EXPANSION (DX) A/C UNITS: VRV-5, 8 & 10

- A. Wall mounted space and discharge air temperature sensors (EMS type) shall be provided and installed under this Section of Specifications for monitoring and alarm purposes only. All split DX units are served by emergency power.
- B. Install, under this section of specifications, a unit manufacturer furnished thermostat, furnished under other sections of these specifications.
- C. The cooling set point shall be 71 Deg. F., adjustable. On a rise in space temperature above set point, energize the cooling system. On a 2 Deg. F., adjustable, drop below cooling set point, the system shall be de-energized and the compressor and fan shall both cycle off, unless other units connected to the same condensing unit are calling for cooling in which case the fan shall cycle off but the compressor will continue to run.
- D. The heating set point shall be 69 Deg. F., adjustable. On a drop in space temperature below set point, energize the heating system. On a 2 Deg. F., adjustable, rise above the heating set point, the system shall be de-energized and the heating system and fan shall

both cycle off, unless other units connected to the same condensing unit are calling for heating in which case the fan shall cycle off but the compressor will continue to run.

- E. All VRV components shall be controlled by unit manufacturer furnished controls to include control of auxiliary heat, where applicable, and defrost cycles, which shall occur as recommended by the unit manufacturer.
- F. For each suspended (above a ceiling) A/C unit, furnish and install a condensate overflow pan water detection, or float switch, which shall de-energize the unit and send an alarm to the EMS when water is detected in the pan.

3.4 SEQUENCE OF OPERATION – AIR CONDITIONING UNIT RE-START AFTER POWER INTERRUPTION

- A. Each A/C unit listed herein shall be controlled with respect to how each unit is sequentially started after power is lost whether utility power resumes shortly thereafter and whenever utility power is switched over to a back-up power generator.
- B. Provide connections and interlock wiring as required to implement the sequence of operations identified herein.
- C. The energy management system shall use internal control logic to control the staggered restart of the A/C units indicated below. Units shall be started in six (6) second intervals, adjustable from five (5) to no more than 30 seconds.
- D. When power is interrupted, each A/C unit, indoor air handling unit coupled with the corresponding outdoor condensing unit (compressor(s)), shall be restarted in the sequence of the list identified below.
- E. The sequence shall reoccur each time power is interrupted.
- F. Interlock with the new generator transfer switch to get feedback as to when generator power is to operate which shall initiate this sequence of operation.
- G. This sequence of operation shall occur at this fire station (Sequence of restarting units being after power loss occurs; in six (6) steps as follows:
 - 1. VRV-1 & 2, coupled with CU-1A
 - 2. VRV-3, 4 & 6, coupled with CU-1B
 - 3. VRV-7 & 8, coupled with CU-2
 - 4. VRV-5, 9 & 10, coupled with CU-3
- H. No other control, for restart after a power failure, of the A/C units or other building mechanical equipment shall occur as a part of this project. Refer to Article 3.7 below for further clarification with respect to new controllers for each A/C unit.

3.5 ELECTRICAL INTERLOCKS

- A. Certain electrical interlocks shall be as listed herein and in other sections of these specifications.
- B. All electrical interlocks shall be made by means of auxiliary contacts on motor starters or shall be accomplished with separate relays unless indicated otherwise. No motor power lead shall be utilized in an interlock circuit, unless indicated otherwise. Each separate control power lead serving a starter shall be provided with a disconnecting switch suitably identified and housed, which may be a toggle switch or other suitable disconnecting device, of proper capacity and number of poles.

3.6 TAB AND COMMISSIONING AGENT SUPPLEMENTARY PROVISIONS

- A. Furnish and install capabilities at each control device to include input and output of all related control devices.
- B. Under this section of the specifications, fully cooperate with the Commissioning Agent in verifying that the units are starting sequentially successfully as specified herein.

3.7 DDC CONTROLLERS

- A. Provide complete DDC Control for all equipment as indicated elsewhere herein.
- B. Not more than one local unitary direct digital controller shall be utilized per piece of equipment, one (1) per A/C unit.
- C. The intent is to have a dedicated controller for each A/C unit which will be able to control two (2) stages of cooling, modulating heat, relative humidity, in some cases carbon dioxide levels, and outside air control dampers. Other parameters to be monitored and controlled will include the space and supply air temperatures, space relative humidity, and interlock with a series of dual technology motion sensors serving each individual A/C unit. Not all items indicated herein are incorporated into the design.
- D. Fire Station shall have at least one (1) controller which shall have its own real time clock.

END OF SECTION

SECTION 23 21 16

CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections, as applicable. Refer to other divisions for coordination of work with other portions of Work.

1.2 SYSTEM DESCRIPTION

- A. Furnish and install all air conditioning condensate piping of every kind required, specified, or shown on the Drawings for the installation of the work specified in Division 23. The location, direction, and size of the various lines are indicated on the Drawings. Auxiliary lines for overflow drains and sensors are not shown but shall be installed as required and as specified elsewhere in these specifications.
- B. Piping systems shall include all appurtenances shown on the drawings and specified herein.
- C. Condensate piping systems shall permit the free drainage of these systems or portions thereof, in the directions as indicated on the Drawings.
- D. The work shall include the furnishing and installing of all supporting structures and members for these piping systems.
- E. Support devices and members shall include vibration and noise isolating devices and assemblies where applicable. Penetrations of walls and structure shall be sealed off to limit noise transmission through sleeves.

1.3 QUALITY ASSURANCE

- A. All piping and materials shall be new and of the best quality.
- B. All piping and materials shall be installed by experienced mechanics certified and trained for the work performed.

1.4 SUBMITTALS

- A. Product Data: Submit complete manufacturer's descriptive literature and installation instructions in accordance with Section 01 30 00 for all piping, soldering materials and methods as specified herein.

B. Shop Drawings:

1. Submit in accordance with Sections 01 30 00 and 23 05 00.
2. Submit 1/4" = 1'-0" Scale HVAC and Plumbing Piping Shop Drawings.
3. Overlay piping Shop Drawings over other Shop Drawings of other trades to include electrical and sheet metal Shop Drawings.
4. Plan views of congested areas and sections thereof shall be drawn at a scale of 3/8" = 1'-0".
5. There is a \$250.00 fee, payable to the engineer to obtain Auto Cad or Revit files for this purpose when requested directly or when requested in addition to the one (1) set that the Engineer provides to the General Contractor or Construction Manager. A "Release of Liability" form must be signed for this purpose after which a single CD, or electronic files, will be produced and transmitted when payment is received. It is recommended that subcontractors pursue these files through the firm they are contracted with as opposed to the Engineer's office.

- C. Fully coordinate all piping shop drawings with sheet metal shop drawings and other trades. Failure to submit shop drawings in a timely manner, as required to keep pace with the construction and work of all other trades, will result in delays, and possible stoppage of work, and potentially payment to the Contractor. Additionally, no work may proceed until such shop drawings are submitted, reviewed, and found to be acceptable by the Engineer.

1.5 PRODUCT HANDLING

- A. Cover and protect materials in transit and at site. Material not properly protected and stored and which is damaged or defaced during construction shall and will be rejected.
- B. Storage and protection of materials shall be in accordance with Section 23 05 00.
- C. Take special precautions to protect the internals of condensate piping from construction dirt and debris. If piping is stored on site cover the open ends until just prior to installation but in no case shall piping be unprotected for more than 24 hours.
- D. Openings in piping system and at condensate drain pan connections shall be covered during the construction period to protect the interior accumulation of dirt and debris in these systems until immediately prior to connection to these components to similarly protected systems or components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. In general, the following listed materials shall be used in fabricating these piping systems. Where special classes of piping are involved and are not listed, the Contractor

shall request instructions as to the class of material involved and the method of fabricating them before ordering the materials:

1. Miscellaneous drains from D/X Split Systems: Type "M" or DWV (1-1/4" and larger) hard drawn copper.
 2. Condensate Drain Piping from all air handling equipment generating condensate: Type "M" or DWV (1-1/4" and larger) hard drawn copper.
- B. Fittings for copper tubing shall be Chase Sweat Fittings, Nibco, Elkhart, or Mueller Brass Company's "Streamline" type solder fittings. Drainage type fittings shall be used wherever possible in drainage systems only. All solder for copper tubing shall be 95% Tin – 5% Antimony and be lead free. All piping shall be installed according to the manufacturer's instructions. All joints shall be thoroughly cleaned before connecting. All elbows shall be the long radius type unless noted otherwise.
- C. Miscellaneous Fittings: Provide all reducers, increasers, adapters, bushings, etc., as required to properly inter-connect the various items, to change sizes, etc. Only copper and red brass fittings shall be used in copper lines.
- D. All piping materials and fittings shall be manufactured in the United States.

2.2 PIPE HANGERS

- A. Pipe hangers shall be as manufactured by Anvil International, Inc. and be of a type suitable for each use. Approved equals by Mason Industries, Inc., B-Line, Grinnell, and PHD Manufacturing, Inc. will be considered.
- B. Condensate piping 3/4" in size up to and including three inches (3"), shall use Anvil Fig. 260, adjustable clevis hangers. Hangers shall be sized to be on the outside of the insulation.
- C. Where several pipes are routed parallel to each other and at the same elevation, trapeze hangers may be used. Where trapeze hangers are used, the pipes shall be supported on rollers where rollers are called for elsewhere herein.
- D. For bare copper drain pipes (uninsulated only) up to and including three inches (3") in size, use Anvil Fig. CT-109 malleable iron, copper plated, split ring, hangers or Anvil Fig. CT-65 copper plated clevis hangers. For uninsulated copper pipes larger than three inches (3"), use Anvil Fig. CT-65 copper-plated clevis hanger.
- E. Hanger rod sizes shall conform to the following schedule:

Pipe up to, and including 2"	3/8" rods

- F. Unless shown otherwise on the Drawings, all horizontal runs of copper piping shall be suspended from the floor or roof construction, as the case may be, by means of hangers with the following maximum spacing:

Pipe up to 3/4" in size	6 feet
Pipe 1" and 1-1/4"	8 feet

- G. There shall be a hanger within two feet (2') of each elbow or tee. Additional supports shall be provided for other accessories as required. Vertical risers shall be supported by approved riser clamps. Vertical pipes within a space shall have not less than two (2) supports. Where the vertical run of pipe in a space exceeds 14 feet then three (3) supports shall be required.
- H. Supports and hangers shall be installed to permit free expansion and contraction in the piping systems. Hangers shall permit vertical adjustment to maintain proper pitch. Where necessary to control expansion and contraction, the piping shall be guided and firmly anchored. No piping shall be self-supporting; nor shall it be supported from equipment connections.
- I. Inserts shall be used where piping or equipment is to be hung from concrete construction. Inserts shall be Anvil Fig. 281, wedge type, concrete inserts. All inserts shall be pre-treated to prevent rusting. After the forms are removed, clip off all nails flush with the exposed surface of the inserts.
- J. Expansion anchors and bolts shall be made by Ackerman-Johnson or Hilti.
- K. Beam clamps suitable for the use with the type of steel construction involved shall be an Anvil product or an approved equal as indicated elsewhere herein.
- L. No perforated straps shall be used to support any mechanical equipment item or piping of any kind.
- M. Condensate drain supports shall be sized to go around the insulation with shields being provided to protect the insulation. Shields shall be Anvil Fig. 167.
- N. All steel hangers, base plates, supports, nuts, bolts, and all thread rod located outdoors, in crawl spaces, and exposed to the weather, shall be made of galvanized steel or

equally suitable corrosion resistant steel alloy or aluminum. Where steel components are allowed and used under these conditions they shall be painted with an equivalent protective coating similar to a two-part epoxy. Refer to Section 09 90 00.

- O. Where applicable, use Anvil Fig. #93 and 94 beam clamps.

2.3 SLEEVES AND ESCUTCHEONS

- A. Generally where pipes pass through interior building walls or floors above the first floor (out of the ground), 22 gauge galvanized sheet metal sleeves shall be used. Sleeves shall extend a minimum one inch (1") above a floor or beyond the wall, as applicable.
- B. All pipes penetrating exterior walls, concrete structural members, or concrete slabs of mechanical equipment rooms on the first floor, shall generally use standard weight galvanized steel pipe as the sleeve material.
- C. For concrete or masonry walls, sleeves shall be inserted into the masonry, decking or form work prior to the pouring or placement of concrete or masonry units to create a leave out.
- D. The sizes of all sleeves shall be such as to permit the subsequent insertion of the intended pipe of the proper size with adequate clearance for movement due to expansion and contraction. In the case of insulated lines, the diameter of the sleeves shall be at least 1/2" greater than the outside walls of the pipe with specified thickness of insulation. Galvanized steel pipe sleeves set in floors shall project two inches (2") above the floor.
- E. After the pipes are installed, fill the annular space between the pipe, and insulation as required, and its sleeve with an approved mastic or caulk. Use loose fibrous insulation packing as required to accomplish this. In all cases the annular spaces around the pipes within the sleeved openings shall be filled with loose fibrous insulation and then sealed with an approved caulking or expanded foam insulation.
- F. Escutcheons, except as specifically noted or specified, shall be installed on all pipes passing exposed through floors, walls, or ceilings. Escutcheons shall be equal to the Crane No. 10, chrome plated sectional floor and ceiling plates, and shall fit snugly and neatly around pipe or pipe insulation or insulated lines. Solid chrome plates with set screws shall be used if sectional plates do not fit properly or stay in place. Where multiple pipes penetrate floors or walls in close proximity in concealed areas, shop made sheet metal escutcheons may be used.
- G. Pipes sleeved through grade beams open to basements, crawl spaces or void spaces below grade shall additionally receive "Link Seal" or equal closures made of interlocking synthetic rubber links. Seals shall provide for absolute water tightness.

Seal shall be constructed to insulate electrically pipe from wall. Install as recommended by manufacturer. Provide Century-Line sleeves with water stop and anchor collar for pipes penetrating grade beams designated to be anchored.

- H. Where small bare uninsulated copper drain piping under two inches (2") in size penetrates a horizontal floor slab a metal sleeve will not be required. For these piping systems, completely wrap the piping with a polyethylene tape, or wrapping. This tape shall be minimum 4 mils thick and shall be wrapped at least two (2) times around the pipe and secured sufficiently to hold the wrap in place during the pouring of the slab. This wrap shall be in sufficient length or height to insure that no concrete will be in contact with the pipe. All other piping shall be sleeved as indicated elsewhere herein.
- I. Refer to Section 23 05 00 for additional requirements of penetrations through fire-rated assemblies.

PART 3 - EXECUTION

3.1 PIPING - GENERAL

- A. Where special classes of piping are involved and are not listed, the Contractor shall request instructions from the Owner's Representative as to the class of material involved and the method of fabricating it before ordering any material.
- B. The location, direction, and size of all lines are generally indicated on the drawings. Branch connections in general are indicated and shall be so installed as to provide proper drainage.
- C. All lines shall be made up straight and true at proper grades. All water filled (pumped condensate) and gravity flow condensate drain lines shall grade down to drains at no less than 1/8" per linear foot of pipe.
- D. Provide cleanouts in each system at not less than 40 feet on centers and each change in direction.
- E. Piping shall follow as closely as possible the routes shown on the plans and take into consideration conditions to be met at the site. Should any unforeseen conditions arise, lines shall be changed or rerouted as required after proper approval has been obtained.
- F. All piping shall be installed with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected.
- G. All screw joints shall be made with taper threads, properly cut. Joints shall be made tight with suitable joint sealant materials.

- H. Dielectric couplings shall be installed where ferrous pipe joins copper lines and shall be rated for the intended medium pressure and temperature or service.
- I. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of systems. No unions will be required in lines assembled with solder joint fittings except at equipment items or coils, machinery items and other special pieces of apparatus. Unions in 2" and smaller lines shall be the ground joint type and unions 2-1/2" and larger shall be flanged. Unions shall be the same material and strength as other fittings in the lines. Companion flanges on lines at various items of equipment, machines, and pieces of apparatus shall serve as unions to permit removal of the particular item.
- J. All piping shall be supported by hangers independently of equipment connections. The weight of the piping and the contents thereof shall not be imposed on the equipment in any way.
- K. Mitering of pipe to form elbows, notching of straight runs to form tees, or any similar construction will not be permitted.
- L. Swing joints or expansion loops shall be provided wherever it necessary to allow for the expansion and contraction of piping. This shall be accomplished in an approved manner and the Contractor shall be responsible for any damage which may occur as a result of expansion and contraction of all piping installed.
- M. Nipples shall be of the same size and material as the piping in the system in which the nipples are installed, except that "close", or "all thread" nipples shall not be used.
- N. Keep all open ends of piping in each system plugged or capped to prevent dirt or other debris from entering the pipe at any and all times during construction and before fixtures or equipment is connected. All piping shall be flushed clear prior to connection to the central building systems.
- O. The ends of all piping furnished and installed in all systems shall be thoroughly reamed to the full inside diameter of the respective pipe.
- P. Exposed and concealed lines shall be run parallel with, and perpendicular to building lines and wherever possible shall be grouped together for easy service and identification. Whenever possible, horizontal and vertical runs shall be held as close as possible to the walls, ceilings, struts, members, etc., so as to occupy the minimum space consistent with the proper installation requirements for insulation, conduit, ductwork, lighting fixtures, etc., and the expansion requirements of each of these items and the building proper or the removal of the respective or adjacent pipes, conduits, and ductwork, and to allow for necessary access to valves, other pipes, conduits, dampers, etc.

- Q. Where new lines are indicated to connect into existing lines, careful coordination shall be exercised to determine exact elevations and locations of existing lines, to establish grades of interconnecting new lines, to establish procedures to interconnect lines, and to establish other details.

3.2 CROSS CONNECTION AND INTERCONNECTIONS

- A. No plumbing fixtures, device, or piping shall be installed which will provide a cross connection or interconnection between a distributing water supply for drinking or domestic purposes and a polluted supply such as drainage system, or a soil or waste pipe which will permit or make possible the backflow of sewage, polluted water, or waste into the water supply system.

3.3 PIPE INSULATION INSERTS AND SHIELDS

- A. Refer to Section 23 07 00, Insulation.

3.4 TESTING AND REPAIRING

- A. During the progress of each portion of the work or upon its completion, make such tests of this work as herein specified, or as required by the Architect, or by State or Municipal Bureaus having jurisdiction and under their supervision.
- B. Provide all apparatus, temporary piping connections, or any other requirements necessary for such tests. Take all due precautions to prevent damage to the building and its contents incurred by such tests as will be required to repair and make good, at no cost to the Owner, any damage so caused. Testing of piping to be insulated shall be done before insulation is applied.
- C. Perform any other tests as may be required by the Owner's Representative to indicate the fulfillment of specification requirements.
- D. All pumped condensate piping shall be hydrostatically tested to a pressure of 100 psig or to 1-1/2 times the operating pressure, whichever is the greatest, for two (2) hours. Gravity condensate piping shall be tested to 50 PSIG for a period of one (1) hour.
- E. Systems shall be tested in portions as required by the construction schedule and the portions being tested shall be effectively isolated and sealed off. When previously tested sections are connected into other sections, tests shall be rerun to include the new connections.
- F. Partial systems shall be tested prior to connecting into existing lines.
- G. Leaks in screwed joints shall be repaired by tightening the joint until the leak has stopped, or by remaking the joint if tightening fails to stop the leak. Leaks in caulked,

or similar sealant, joints shall be completely stopped by additional caulking or sealing of the joint, but, if that fails, the joint shall be re-made. A leak in a compression joint shall be repaired by remaking the joint using a new seal, compression ring, coupling, etc., as required. Leaks in soldered joints shall be repaired by remaking the joint and no soldering or brazing over existing joints will be permitted. Any defective piping shall be replaced.

- H. Additional testing may be as specified in other individual Sections of these Specifications.

3.5 SEALING PENETRATIONS

- A. Seal all pipe and duct penetrations through walls run to structure, ceilings, floors and roofs. Fill the annular space between the insulation on the pipe, or the pipe only where uninsulated, or duct and its sleeve, with neoprene or non-hardening sealant.
- B. No pipe or duct shall be allowed to contact its surrounding sleeve or the wall, floor, or ceiling. Effective isolation shall be provided as described in Section 23 05 48 to the end that no vibration or direct noise transmission shall be transmitted. Vibration transmission limits shall be as established in Section 23 05 48. Use special materials as may be required to comply.
- C. Firestop pipe floor and wall penetrations as specified in Section 23 05 00.

3.6 PAINTING

- A. All equipment specified in Division 23 shall be delivered to the site with suitable factory finishes as specified elsewhere herein. Refer to drawing notes to identify where condensate piping systems, to include insulation, may require painting.
- B. Items with factory applied finishes shall be protected during installation and other construction work. Damaged factory applied finishes shall be refinished to match the original finish appearance.
- C. Field painting of items specified and installed in Division 23 shall be as per industry standards.
- D. All ferrous metals that are not galvanized or made of a corrosion resistant alloy shall be painted. This shall include steel pipe hangars, trapeze supports, pipe stands, all thread hangar rods and other miscellaneous systems.

END OF SECTION

SECTION 23 23 01

VRV/VRF REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for VRV/VRF air-conditioning applications.

1.2 PERFORMANCE REQUIREMENTS

- A. Suction (low pressure gas) Lines: 550 psig, or per equipment manufacturers recommendation.
- B. Hot-Gas (high pressure gas) and Liquid Lines: 550 psig, or per equipment manufacturer's recommendation.

1.3 SUBMITTALS

- A. Product Data: Provide for each type of valve and refrigerant piping specialty indicated.
- B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, valve arrangements and locations, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

1.5 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube:
 - 1. Straight Lengths: ASTM B 75, UNS C12200, H55 Temper (Light Drawn), ACR Bending Quality; Cleaned, Eddy Current Tested, and Plugged per ASTM B 280.
 - 2. Coiled: ASTM B 280, UNS C12200, O60 Temper (Soft Annealed), ACR, cleaned and capped.
- B. Mechanically Attached Fittings:
 - 1. Brass Body mechanically attached fittings, ETL Listed, per UL-207 with an allowable working pressure of 1,167 psi.: Refrigerant Coupling Systems, Inc. (RCS) couplings, reducers, and flare fittings.
 - 2. Primary seal shall be metal to metal seal. Use of O-ring seals is not permitted.
- C. Field Bends (all angles): ASME B31.5.

2.2 VALVES AND SPECIALTIES

- A. Service Valves:
 - 1. Body: Forged brass with brass cap.
 - 2. Core: Removable ball-type check valve with stainless-steel spring.
 - 3. Seat: Polytetrafluoroethylene.
 - 4. End Connections: Straight ends.
 - 5. Working Pressure Rating: 700 psig.
 - 6. Maximum Operating Temperature 250 deg. F
 - 7. Valves must be specifically rated for R-410A.

2.3 REFRIGERANTS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Fittings shall be suitable for use with CFC, HCFC, HFC, HFO and R744 (CO2) refrigerants within the design pressure rating. Fittings shall be suitable for use with Refrigerant class A2L (mildly flammable).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Suction (low pressure gas), Hot Gas (high pressure gas) and Liquid Lines OD 5/8" and Smaller for Conventional Air-Conditioning, Heat Pump, and Heat Recovery
Applications: Copper, Type ACR, O60 (soft annealed)-temper tubing and field bent fittings with mechanically attached joints.

- B. Suction (low pressure gas), Hot Gas (high pressure gas), and Liquid Lines OD 1-5/8" and smaller for Conventional Air-Conditioning, Heat Pump, and Heat Recovery Applications: Straight Lengths, Copper, Type ACR Type L, H55 (light drawn)-temper tubing and field bent fittings with mechanically attached joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves as shown on plans or as required to isolate system components.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls.
- E. Install piping above accessible ceilings to allow enough space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Field Bend changes in direction.
- I. Select system components with pressure rating equal to or greater than maximum allowable working pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- L. Provide Jacketed insulation in locations where exposed to mechanical injury.
- M. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

- N. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."
- O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."
- R. Provide proper compensation for pipe/tube expansion and contraction per equipment manufacturers recommendations.

3.4 PIPE JOINT CONSTRUCTION

- A. Mechanically Attached Joints: Construct joints with approved mechanically attached fittings as described above.
- B. Field Bends: Fabricate field bends with a center-line bend radius greater than or equal to 4 times the nominal OD of the pipe or tube. Tube shall be bent with a tubing bender sized for ACR OD tube sizes and shall not cause cracks or wrinkles in the tube or pipe. Do NOT use a conduit bender for bending ACR copper. The difference between maximum and minimum diameters for pipe bends should not exceed 8% of the nominal outside diameter of the pipe. Only O60 soft annealed-temper and H55 light drawn-temper shall be field bent. Do NOT field bend H58 drawn general purpose-temper copper tube.
- C. Joining Procedure
 1. Tube ends shall be cut with a clean sharp tubing cutter.
 2. Deburr the I.D. of the cut tube end with a clean, sharp deburring tool.
 3. Visually inspect the interior of each tube for obstructions and debris before assembly. Protect the joint from contamination before assembly.
 4. Visually inspect the exterior of each tube end receiving a fitting. This tube end must be clean, free of burrs, scratches, pits, or deformation. End of fitting must be round.
 5. Install joint in strict compliance with Refrigerant Coupling Systems, Inc. installation instructions.
- D. Thermal Insulation and Vapor Barrier
 1. Insulate piping as required by equipment manufacturer, local codes and authority having jurisdiction.

2. Strictly comply with insulation manufacturers installation instructions to provide a vapor proof insulation system.
3. If properly sealed vapor proof insulation system is not possible, mechanically attached fittings installed outdoors or in extremely humid environments should be protected with cold shrink sleeves, or heat shrink sleeves.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 1. Adjustable steel clevis hangers for individual horizontal runs.
 2. Rigid high compressive strength foam insulating pipe support at all support points. Comply with Section 230719 "DX Piping System Insulation".
 3. Do NOT attach hangers directly to pipe or tube.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 1. Up to 3/4" OD: Maximum span, 60 inches; minimum rod size, 3/8 inch.
 2. Greater than 3/4" thru 1" OD: Maximum span, 72 inches; minimum rod size, 3/8 inch.
 3. Greater than 1" thru 2-1/8" OD: Maximum span, 96 inches; minimum rod size, 3/8 inch.
- D. Support multi-floor vertical runs every 10 feet and at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Comply with ASME B31.5, Chapter VI.
 2. Test as recommended by equipment manufacturers instructions.
 3. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - a. Fill system with 95/5 nitrogen/hydrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test all joints and fittings with hydrogen leak detector, at test pressure.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures and per equipment manufacturers instructions.

1. Evacuate (triple evacuation procedure) entire refrigerant system with a vacuum pump to obtain a steady state vacuum of less than 500 micrometers. If vacuum holds for 12 hours, system is ready for charging. Do NOT evacuate the system through a charging manifold. Use only suction rated hoses and core removal tools.
2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
3. Charge system as recommended by equipment manufacturer.

END OF SECTION

SECTION 23 30 00

HVAC AIR DISTRIBUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other portions of work.

1.2 SYSTEM DESCRIPTION

- A. The scope shall include the furnishing and installation of all ductwork as shown on the Drawings; acoustical and thermal linings; flexible ducts and connections; combination smoke and fire dampers, smoke dampers, and fire dampers; duct access doors; air diffusers, grilles and registers; air volume control devices; hangers and supports; plenums and casings; turning vanes; air filters; installation of temperature control dampers, and other appurtenances necessary for a complete and operational system.
- B. All work shall be preceded by taking measurements at the job site, fully coordinating all work with other trades, verifying available spaces for ductwork, and developing Shop Drawings illustrating such.

1.3 QUALITY ASSURANCE

- A. All equipment and materials shall be new and of the quality as specified herein. All work shall comply with the most recent Local Building Code, Mechanical Code, Fire Code, and all other applicable National, State and Local Codes or ordinances.
- B. All equipment and materials shall be installed in a workmanlike manner by trained and experienced sheet metal technicians and mechanics as recommended by the manufacturers of the products installed.
- C. Where the standards and requirements of this specification exceed those of the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) the requirements herein shall govern. As a minimum all ductwork shall be constructed to meet all functional criteria defined in Section 11 of the 2005 SMACNA "HVAC Duct Construction Standards, Metal and Flexible," Third Edition. However, all ductwork shall comply with all code requirements noted above to include meeting deflection limits established in the local Mechanical code.

- D. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job, "Substantial Completion", against noise, chatter, whistling, or vibration, and free from pulsation under all conditions of operation. After the system is in operation, should these defects occur, they shall either be removed and replaced or reinforced as directed by the Owner's Representative.
- E. Air quantities shown on the Drawings, or specified, are based on air at 75 Deg.F. dry bulb, 50 percent relative humidity, and 29.92 inches H.G. barometric pressure.
- F. Except where specified otherwise, all sheet metal used shall be constructed from prime galvanized steel sheets or coils up to 60 inches in width. Each sheet shall be stenciled with manufacturer's name and gauge. Coils of sheet steel shall be stenciled throughout on 10 foot centers (fabricate with stencils to the outside of the ductwork so they are visible when installed) with manufacturer's name and gauge tolerances in inches:

Gauge No.	Nominal Thickness	Minimum Thickness
26	0.0217	0.0187
24	0.0276	0.0236
22	0.0336	0.0296
20	0.0396	0.0356
18	0.0516	0.0466

- G. Contractor shall comply with this specification section in its entirety. If during a field observation, the engineer of record finds changes have been made without prior written approval, the contractor shall make the applicable changes to comply with this specification at the contractor's expense.
- H. At the discretion of the Engineer of Record, sheet metal gauges and reinforcing may be randomly checked to verify all duct construction is in compliance with this is specification section.
- I. All ductwork and fittings shall have a computer generated label affixed to each section detailing all applicable information including the duct dimensions, gage, reinforcement type/class, and connector type of the systems manufacturer. In addition, galvanizing thickness and country of origin shall be clearly stenciled on each duct section.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions in all items specified herein in accordance with Section 23 05 00.

- B. Shop Drawings shall be submitted on all items of sheet metal work specified herein. Shop drawings of ductwork shall be submitted at a minimum scale of 1/4" equal to one foot except that the Congested Areas and all Air Handling Unit Mechanical Rooms shall be submitted at a minimum scale of 1/2" = 1'-0". Provide sections for all Congested Areas and Mechanical Room Plans.
- C. Shop Drawings shall include the reflected ceiling plan, screened back, overlaid onto the floor plan indicating the proposed installation of all light fixtures; ductwork layout; duct fittings; duct connection details; offsets; bottom of duct elevations; all sheet metal dimensions (sizes); overall air device sizes, air device neck sizes, air device air flow quantities, and device type; duct pressure classifications; all mechanical piping; any conflicts discovered and unresolved through the use of transitions and offsets in the available space; turning vanes; manual volume dampers; automatic control dampers; smoke and fire dampers; duct access doors; flexible connections; and all mechanical fans and equipment.
- D. Sheet metal shop drawings shall be overlaid on piping shop drawings and other shop drawings for other portions of work specified in other sections of these specifications for complete coordination of all work prior to commencing with any installation. These Shop Drawings shall not be prepared directly on the Shop Drawings of other trades; they will be separate from all other shop drawings. Coordination Drawings shall be prepared in accordance with Specification Sections 01 31 00 and 01 33 00.
- E. Shop Drawings shall be based on actual field measurements taken at the job site and shall take into consideration all obstacles and be fully coordinated with all piping, conduits, structure, equipment, and general construction features.
- F. Shop Drawings shall be generated by a computer aided design and drafting (CADD) system as a CADD drawing. CADD files with Architectural Backgrounds and Mechanical design drawing files will only be provided when requested, if this privilege has not been previously abused, after a Release of Liability Form has been completed and the Contractor agrees to pay a fee associated with the cost to furnish these files, typically a minimum \$100.00 fee, up to \$500.00, depending on file size. The fee on this project for HVAC ductwork and piping CADD files will be \$100.00.
- G. Include a brochure, with individually assembled cut sheets, and details of all sheet metal fittings, duct construction standards proposed for each system, air volume control devices, and other accessories proposed to be used for job duct construction standards. This shall be done prior to submission or preparation of any sheet metal shop drawings.
- H. Should any ductwork installation commence without approved ductwork shop drawings or written approval by the Engineer of Record, the Contractor assumes all liability, to include all costs, in revising any portion of the sheet metal work that is deemed

unacceptable by the Owner's Representative to include any conflicts discovered in installation that could have been resolved through the Shop Drawing process.

1.5 GUARANTEE

- A. The work shall be guaranteed for a period of one (1) year from and after the date of acceptance of the job, "Substantial Completion", against noise, chatter, whistling, or vibration, and be free from pulsation under all conditions of operation. This guarantee shall include defects in material, equipment and workmanship.
- B. After the system is in operation, should these defects occur, they shall either be removed and replaced or reinforced as directed by the Owner's Representative. This shall include repair of damages to building materials related to these deficiencies.

1.6 PRODUCT HANDLING

- A. Cover and protect material in transit and at site. Material not properly protected and stored, which has been damaged or defaced, or which has gotten wet during storage or construction shall be rejected.
- B. All ductwork shipped to the job site shall be stored in trailers or storage buildings or under roof decking or solid floors located above the floor. All open ends of ductwork shall be wrapped in 3 MIL plastic and supported on stands to keep the ductwork a minimum of four inches (4") above the support surface below.
- C. No ductwork shall be installed until the roof system, or the floor above the ductwork, is installed more than ten feet (10'-0") beyond the further extent of where the ductwork will be installed.
- D. All openings in all ducts shall be completely covered with minimum three (3) MIL thick plastic during construction. All open ends, where opened to allow further installation of new ducts, shall be covered with this same plastic at the end of each day.
- E. Whenever duct systems are operated during construction, all open ends of the ductwork shall be covered with flexible filter media equivalent to MERV 11 filter media. These filters shall not be removed except to make final duct tie-ins and only with the building envelope completely enclosed.
- F. Storage and protection of materials shall be in accordance with Section 23 05 00.

PART 2 - PRODUCTS

2.1 DUCTWORK

- A. General:

1. All ductwork shown on the Drawings, specified or required for the heating, ventilating, and air conditioning systems, shall be constructed and erected in a first-class workmanlike manner by trained and skilled sheet metal workers.
2. All ducts shall be erected in the general locations shown on the Drawings, but must conform to all structural and finish conditions of the building. Before fabricating any ductwork, Contractor shall check the physical conditions of the job site, and shall make all necessary changes in cross sections, offsets, etc., whether they are specifically indicated or not.
3. Before starting shop drawings or fabrication of any ductwork, the Contractor must have an approved reflected ceiling plan with which he can coordinate location of air outlets, lights, tile patterns, etc.
4. The sizes of ducts indicated on the Drawings are the required net internal air stream dimensions, and where ducts are lined, the sheet metal sizes shall be increased three inches (3") in both dimensions to accommodate the linings (1-1/2" thick lining, unless indicated otherwise). Assume all rectangular ducts are lined unless noted otherwise.
5. Ductwork shall be classified, for construction standards, as follows:
 - a. Medium pressure from variable air volume supply fan (AHU) discharge up to the variable air volume terminals. This ductwork shall be constructed to withstand up to six inch (6") W.G. standards.
 - b. All other ductwork for constant volume air handling equipment and all constant and variable air volume air handling unit return, relief and outside air intake ductwork are operating at pressures up to two inches (2") W.G., classified as low pressure ductwork, and shall be constructed to two inch (2") W.G. standards.
 - c. All exhaust ductwork, except grease or other special exhaust systems specified elsewhere herein, all ductwork downstream of variable air volume terminals, all constant volume ductwork (supply and return) served by packaged rooftop units, split direct expansion (supply, return and outside air) A/C units, all ductwork served by fan coil units, and all transfer air ducts shall be constructed to meet one inch (1") W.G. standards.
 - d. All large centralized exhaust duct systems serving multiple floors and a large number of outlets, more than 10, shall be constructed to meet two inches (2") construction standards. This duct work shall also be pressure tested (positive air pressure) at two inches (2"). Leakage shall be limited to no more than 5% maximum.
6. Except as noted otherwise, ducts, plenums, and casings shall be constructed of new lock forming quality galvanized prime grade steel sheets. The gauges of metal to be used, duct construction details, and the construction and bracing of joints shall be in accordance with the latest edition of the published standards of the ASHRAE Handbook or in accordance with the latest editions of Sheet Metal and Air

Conditioning Contractors' National Association (SMACNA) "Duct Construction Standards Manual, Metal and Flexible".

7. Plenum chambers shall be constructed of 18 gauge sheets thoroughly braced with 1-1/2 inch angle irons. All duct panels in rectangular galvanized steel ducts which are 12 inches and wider and which are not lined shall be cross broken.
8. Make square elbows where shown or required, with factory fabricated double thickness turning vanes. Job fabricated vanes will not be acceptable. Except as otherwise specified or indicated on the drawings, make all other changes in direction with rounded elbows having a centerline radius equal to 1-1/2 times the width of the duct in the plane of the bend.
9. Make transformations in duct shape or dimension with gradual slopes on all sides. Normally, make increases in dimension in the direction of air flow, with a maximum slope of one inch (1") in seven inches (7") on any side. Where conditions prevent the normal slope specified above, a maximum slope of one inch (1") in four inches (4") will be allowed only where conditions necessitate.
10. Where a transition must be made with less slope than that noted above, install single thickness guide vanes to insure proper air flow, and to minimize air pressure drop. Transitions that require less slope than that noted above shall be noted on Shop Drawings, and require review and approval by the Engineer prior to installation.
11. Ducts shall be routed in conjunction with all types of pipes, electrical conduits, ceiling hangers, etc., so as to avoid interferences insofar as possible. When duct penetrations are unavoidable, provide streamline-shaped sleeves around such material penetrations, made airtight at duct surfaces, except that such sleeves are not required at tie rods. When the Contractor believes such penetrations are unavoidable, notify the Owner's Representative for approval prior to commencing with such work. Otherwise all such penetrations are not expected to occur and are not allowed. Such penetrations will not be allowed for the convenience of, or lack of coordination by, the Contractor. Where obstructions necessitate, are approved by the Owner's Representative, and are of a size exceeding 10% of the total duct area, the duct shall be transformed to maintain the same original duct area.
12. Where each duct passes through a fan room wall, it shall be wrapped with not less than 1/2" thick closed cell neoprene tightly fitted to the outer surface of the duct all around and sealed. In lieu of this method, completely fill the annular space between the duct and penetration by packing with fibrous insulation and seal the perimeter of the penetration around the duct, on both sides of the penetration, with a flexible non-hardening sealant, to be fire rated when applicable.
13. All outlets or grilles in ceilings shall be supported rigidly from ceiling construction with suitable adapters or bucks installed as necessary and as shown to ensure outlets and grilles will be accurately trued up with ceiling.
14. Ductwork shall be fabricated in a manner to prevent the seam or joints being cut for the installation of grilles or diffusers.
15. All sheet metal ductwork shall be securely hung from the building construction. All ducts shall be hung adjacent to the seam in the duct and shall be secured in a suitable manner to both the duct and the building construction. All vertical riser ducts shall be supported at each floor with angle iron secured to the ducts and set

- on the structure members. These angles shall be the same size as specified for bracing.
16. All holes in ducts for damper rods and other necessary devices shall be either drilled or machine punched (not pin punched), and shall not be any larger than necessary. All duct openings shall be provided with sheet metal caps if the openings are to be left unconnected for any length of time. All panels of uninsulated ducts twelve inches (12") and larger shall be cross broken. In general, sheet metal screws shall not be used in duct construction unless the point of the screw is in the air stream unless specifically indicated otherwise elsewhere herein.
 17. Manual dampers shall be installed as shown on the Drawings and as required to afford complete control of the air flow in the various duct systems. In rectangular supply ducts, a splitter damper shall be installed at each point where a branch is taken off and additional volume dampers shall be installed where shown or required to achieve the final air balance. No splitter dampers shall be installed in medium pressure ductwork, unless specifically shown on Drawings.
 18. Splitter dampers and volume dampers of the "butterfly" type, installed in rectangular ducts, shall be constructed of 16 gauge galvanized steel riveted or welded to square operating rods. Dampers shall have brass, bronze, or approved plastic bearings. The length of any splitter damper blade shall be 1-1/2 times the width of the smaller split in the duct, but shall be not less than twelve inches (12"). Where splitter dampers exceed 12 inches in height two (2) pull rods shall be used. Splitter dampers 12 inches (12") in height or less shall have one (1) pull rod.
 19. Butterfly damper blades in round ducts shall be the full width of the duct in which they are installed. Dampers shall be constructed of a minimum 22 gauge metal. Dampers over twelve inches (12") in diameter shall be constructed of 20 gauge metal, have a continuous rod with end bearings opposite the damper handle, and a quadrant type locking handle.
 20. The operating rods of all dampers shall be fitted with Young Regulators and the operating head shall be securely fastened in place so as to be accessible in the finished building unless shown otherwise. Operators shall be attached to duct where regulator occurs above a lay-in ceiling.
 21. Use a Ventlok No. 555 locking quadrant on accessible concealed splitter dampers.
 22. Where locking quadrants are installed on externally insulated ductwork a hat channel extension shall be used to match the same height as the insulation thickness.
 23. Where dampers occur above or behind plaster or other inaccessible ceilings, walls, chases or furrings, provide a Bowden Cable Remote Control System to allow proper air balance. The remote regulator shall be the concealed type with adjustable cover plate equal to Young Regulator Company Type 315 with maximum 2-1/2" diameter cover plate and required accessories. In lieu of the manual remote control cable system provide an electronically operated remote control balance damper powered by a hand held controller using battery power to stroke the low voltage damper motor located at the balance damper, similar to the Young Regulator, Model EBD.
 24. Young Regulator bearings shall also be provided on the opposite end of each operating rod.

25. Behind each ceiling supply outlet, provide and install a turning vane or approved equalizing grid, where noted or scheduled. Where adjustable air pick-ups are indicated at points branch ducts meet trunk ducts, they shall be Titus AG-45 or approved equal with operator adjustable from the duct exterior.
26. Rectangular opposed blade volume dampers shall be as manufactured by American Warming and Ventilating or Ruskin. Blades shall not exceed 48 inches in length or twelve inches (12") in width, and shall be the opposed interlocking blade type. The blades shall be of not less than No. 16 gauge steel supported on one-half inch (1/2") diameter rustproofed axles. Axle bearings shall be the self-lubricating ferrule type.

B. Medium Pressure Ductwork:

1. Rectangular medium pressure ducts shall be constructed of the following gauges:

Largest Dimension of Duct	Gauge of Metal	Maximum Reinforcement Spacing
Up thru 22"	24	4'-0"
23" thru 30"	24	3'-0"
31" thru 36"	24	2'-6"
37" thru 48"	22	2'-6"
49" thru 60"	22	2'-0"
61" thru 72"	20	2'-0"
73" and Up	18	2'-0"

Additional reinforcing shall be per current SMACNA Requirements.

2. The above rectangular ducts shall be constructed in accordance with the requirements of Section 1 of the most recent edition of SMACNA "HVAC Duct Construction Standards Manual, Metal and Flexible". However, the gauge thickness of the ductwork shall meet that as scheduled above. Reinforcing method shall be in accordance with the most current SMACNA standards for the duct classification being constructed taking into account the duct dimensions and gauge thickness; without tie rods through 60 inch sizes and using tie rods 61 inches and over to keep reinforcing angles to 2" maximum.
3. Sealant (MMM EC-800, Hardcast "Iron-Grip 601", Childers CP-146, Foster 32-18, or Polymer Adhesive Sealant Systems, Inc. "Air Seal No. 11") shall be used at all joints on rectangular or round ducts in shop and field fabrication and shall be installed:
 - a. In the joint prior to closing to provide a positive seal for slide-on round or oval joints.
 - b. Externally seal all longitudinal and transverse duct joints after these joints are closed.

- c. Where "Ductmate" joints are used seal external to joints after the joint is closed as needed to repair all audible leaks and to comply with the leakage test requirements. Use double sealant at corners of these joints.
 - d. All sealants shall be U.L. listed and labeled in accordance with U.L. 181 for duct sealant.
4. Round medium pressure duct construction, gauges and reinforcing shall be in accordance with Section 3 of the most recent edition of SMACNA "HVAC Duct Construction Standards Manual, Metal and Flexible". Straight ducts and fittings shall be of the same manufacturer. Spiral wound ducts shall be used up to 48" in diameter and shall be as manufactured by United Sheet Metal Company or approved equals. Joints shall be joined by approved couplings secured by sheet metal screws and sealant. Ninety degree branch take-offs shall be made with conical tees. Take-off fittings shall be welded to fittings or to the main duct. All welds shall be cleaned and coated with rust-inhibiting paint. Elbows shall be stamped smooth type, or 5 or 3 piece gore type, with either type having a center line radius of 1-1/2 times the duct diameter. Ducts shall be constructed with four-ply reinforcing spiral lock seams. Fittings shall be as manufactured by United Sheet Metal Company, Ward, or approved equals only.
5. Flat oval medium pressure ducts, if used, shall be spiral flat oval or welded flat oval as manufactured by United Sheet Metal Company with gauges and reinforcing as recommended by the manufacturer for medium pressure duty. The ducts may, also, be shop fabricated of completely welded construction of the following gauges with no reinforcing:

Minor Axis of Duct	Gauge of Metal
6" to 10"	24
11" to 16"	22
17" to 24"	20
25" to 36"	18
37" and Up	16

Fittings shall be as manufactured by United Sheet Metal Company, Ward or approved equals only with requirements, sealing, etc., similar to that specified for round medium pressure ductwork. Fittings shall be matching type manufactured with continuous welds.

6. Medium pressure duct supports:
- a. All horizontal medium pressure rectangular ducts shall have duct hanger requirements as follows:

Maximum Duct Dimension	Minimum Hanger Size	Hanger Size Galv. Steel Strap Width	Maximum Spacing	No. Hangers	Minimum Trapeze Size
Up thru 18"	---	1" x 16 Ga.	10'	2	----
19" to 36"	---	1" x 16 Ga.	10'	2	----
37" to 60"	3/8"	1" x 16 Ga.	8'	2	2 x 2 x 1/4
61" to 120"	3/8"	1-1/2" x 12 Ga.	8'	2	2 x 2 x 1/4
121" to 240"	3/8"	----	4'	2	2-1/2x2-1/2x3/16

- b. All horizontal medium pressure round ducts shall have duct hangers spaced 10'-0" maximum, with requirements as follows:

Duct Diameter	Hanger Size	Minimum No. Hangers	Hanger Ring Size
Up to 18"	1" x 16 Ga.	2	1" x 16 Ga.
19" to 36"	1" x 12 Ga.	2	1" x 12 Ga.
37" to 50"	1-1/2" x 12 Ga.	2	1-1/2" x 12 Ga.
51" to 84"	1-1/2" x 12 Ga.	2	Support Bracing Angle

- c. Hanger straps on duct widths of 60 inches and under shall lap under the duct a minimum of one inch (1") and have a minimum of one fastening screw on the bottom and two on the side.
- d. Hanger straps on ducts with widths over 60 inches shall be bolted to duct reinforcing with 3/8" bolts minimum.
- e. Use 3/8" minimum bolt for securing round duct hanger straps to band straps.
7. Where galvanized steel ductwork or joints are welded use "Everdur" welding rods.

C. Low Pressure Ductwork:

1. Rectangular low pressure ducts, systems designated to be operating at up to two (2) inches W.G., shall be constructed of the following medium gauges:

Largest Dimension of Duct	U.S. Gauge of Metal	Maximum Reinforcement Spacing
Up to 26"	26	5'-0"
27" to 42"	24	4'-0"
43" to 48"	22	4'-0"
49" to 60"	20	4'-0"
61" to 84"	18	4'-0"
85" to 96"	18	3'-0"
97" and Over	18	2'-6"

The above rectangular ducts shall be constructed in accordance with Section 1 the latest edition of the "Duct Manual" published by the Sheet Metal and Air Conditioning Contractors National Association. However, the gauge thickness of the ductwork shall meet that as scheduled above.

2. Rectangular low pressure ducts, for systems designated to be operating at up to one (1) inches W.G., shall be constructed of the following medium gauges:

Largest Dimension of Duct	U.S. Gauge of Metal	Maximum Reinforcement Spacing
Up to 36"	26	5'-0"
37" to 48"	24	5'-0"
49" to 60"	24	4'-0"
61" to 72"	22	4'-0"
73" to 84"	20	4'-0"
85" to 96"	18	4'-0"
Over 96"	18	2'-6"

The above rectangular ducts shall be constructed in accordance with Section 1 the latest edition of the "Duct Manual" published by the Sheet Metal and Air Conditioning Contractors National Association. However, the gauge thickness of the ductwork shall meet that as scheduled above.

3. Round low pressure ducts shall be spiral wound as manufactured by United Sheet Metal Company or have grooved seams with flat snaplock longitudinal seams. Spiral seam round duct gauge thicknesses shall be that standard by the manufacturer for the pressure rating of the system. Gauges for snaplock shop fabricated ducts shall be as follows, without exception:

Largest Dimension of Duct	Gauge of Metal	Gauge of Longitudinal Seams and Fittings
Up thru 8" in Diameter	26	26
9" to 14"	26	24
15" to 26"	24	22
27" to 36"	22	20
37" to 50"	20	18
51" to 60"	18	16

Elbows shall have a centerline radius of 1-1/2 times duct diameter or width and for round ducts may be smooth elbows or 5 piece 90 degree elbows and 3 piece 45 degree elbows. Joints of round ducts shall be slip type with a minimum of three (3) sheet metal screws.

4. All low pressure ductwork shall be externally sealed using water based products to include, United McGill Corporation United Duct Sealer, Hardcast "Iron-Grip 601", Childers CP-146, Foster 32-18 or Polymer Adhesive Sealant Systems, Inc. "Air Seal No. 11" duct sealer installed in the joints after closure. All sealants shall be U.L. rated for the application. Seal all external transverse joints, longitudinal seams, and all fitting connections externally to include sealing all duct work accessories, connections to accessories and duct and accessory penetrations (tubes, rods, wires, etc.). Do not seal control rods for actuated dampers and fasteners. Each system shall meet a seal class of "A".
5. Low Pressure Duct Supports:
 - a. All horizontal ducts up to and including 40 inches in their greater dimension shall be supported by means of No. 18 U.S. gauge band iron hangers attached to the ducts by means of screws, rivets or clamps, and fastened above to inserts, toggle bolts, beam clamps or other approved means. Duct shall have at least one pair of supports 8'-0" on centers. Clamps shall be used to fasten hangers to reinforcing on sealed ducts.
 - b. Horizontal ducts larger than 40 inches in their greatest dimension shall be supported by means of hanger rods bolted to angle iron trapeze hangers. Duct shall have at least one pair of supports 8'-0" on centers according to the following:

Angle Length	Angle	Rod Diameter
4'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
6'-0"	1-1/2" x 1-1/2" x 1/8"	1/4"
8'-0"	2" x 2" x 1/8"	5/16"
10'-0"	3" x 3" x 1/8"	3/8"

- c. Vertical ducts shall be supported where they pass through the floor line with 1-1/2" X 1-1/2" X 1/4" angles for ducts up to 60". Above 60" the angles must be increased in strength and sized on an individual basis considering space requirements.
 6. All low pressure ductwork shall be reinforced to maintain a maximum reinforcement spacing as scheduled with the rigidity classification as needed to meet the specification construction standard. Reinforcement spacing shall be reduced as required to meet the construction standard specified using the gauge thickness scheduled.
- D. Round Flexible Insulated Ductwork:
1. All round flexible insulated ducts, low and high pressure type, shall be factory fabricated and insulated as manufactured by Thermaflex or Flexmaster USA, Inc. Flexible ducts shall be equal to Thermaflex factory insulated type "M-KC" or Flexmaster "Type 3M".
 2. Flexible duct thermal conductance shall be based on a 75 Deg. F. mean temperature and an aged condition (not out of the box value). Flexible duct insulation shall be a minimum nominal two inches (2.0") in thickness with a minimum 0.75 lb. density. The completed duct assembly shall have a minimum R-value of 6.0. To verify compliance with the Energy Conservation Code in effect, the minimum R-value of 6.0 will need to be documented on the outside of the jacket to allow field verification of compliance with this requirement.
 3. The core liner of the flexible duct system shall be a tri-laminate aluminum foil, made with fiberglass and aluminized polyester, or a PVC coated fiberglass cloth. The outer liner shall be a polyester reinforced aluminized foil jacket.
 4. Flexible ducts shall be U.L. Listed in accordance with U.L. 181 as a Class I insulated air duct, and shall comply with NFPA Standard 90A and 90B. Flexible ducts shall have a maximum flame spread of 25 and maximum smoke developed rating of 50.
 5. Flexible ducts shall be suitable for operating temperatures of -20 up to 250 Deg. F.
 6. Flexible ducts shall be suitable for negative pressures of minus one inch W.G. in sizes up to 16" in diameter; and positive pressures up to 10 inches W.G. for sizes up to 16" in diameter. Maximum operating duct velocity rating shall be a minimum of 4,500-5,500 feet per minute.
 7. Maximum vapor transmission rating shall be 0.05 Perms as rated in accordance with ASTM-E-96.

8. Unless otherwise noted, the maximum length of flexible duct shall be limited to five feet (5').
9. Securement of flexible ducts to air devices shall consist of sliding the duct onto the air device collar or connector and securing it with plenum rated nylon or teflon panduit band on the inner liner which shall be U.L rated for the application. Fold insulated outer vapor barrier jacket liner over the first band and secure with a second plenum rated panduit band. Make connection vapor tight with a vapor barrier seal using polyester reinforced aluminized duct tape that is two inches (2") wide, wrapped 2 times around the duct, or by the use of a fiberglass mesh wrapped in a similar fashion and coated with a vapor barrier coating, Foster's Vapor Safe 95-90 or 95-96 mastic or Childers CP-38. Coating must adhere to MIL-PRF-19565C with a permeance rating of less than 0.02 perms per ASTM-E-96, procedure B. No cloth backed duct tape is allowed. All fasteners, adhesives, and duct tape used shall be U.L. rated for the application. All duct tapes used shall be acrylic based.

2.2 ROUND LOW PRESSURE DUCT TAPS

- A. Provide round low pressure, systems operating at a maximum of two inches (2" inches) water gauge (W.G.) static pressure, duct taps to serve air devices where shown on the drawings and in accordance with details for these taps
- B. Duct taps shall consist of spin-in, or spin on, collar type manufactured fittings specifically made for commercial ductwork systems. Spin-in fittings shall be the conical type as shown and detailed on the drawings to include integral manual balance damper with locking device. Fittings shall be fabricated using continuous weld longitudinal seams. No riveted construction allowed.
- C. All spin-in fittings shall be made with hot dipped, G-60 or G-90, galvanized steel (per ASTM A 653) and be a minimum of 26 gauge in thickness for all sizes from 4" to 12" round. All sizes 14" to 20" round shall be a minimum of 24 gauge in thickness. Thicker gauges shall be provided on larger fittings as required per SMACNA and the Mechanical Code, where required.
- D. Provide plain or beaded ends for connection of duct work as required for the application. Crimped ends are not allowed.
- E. All ductwork systems are called out elsewhere in these specifications to be externally sealed to limit air leakage. These fittings may either be factory sealed (all seams sealed) or be sealed by the contractor in the field.
- F. All spin-in fittings shall also include integral manual balance dampers unless indicated otherwise. Damper options shall be as follows:
 1. All manual volume dampers shall be the butterfly type, using a single round damper blade and positive locking regulator damper hardware.
 2. Sizes 4"-12" round shall have a reinforced damper axis (not a continuous damper shaft) with 1/4" regulator and spring loaded, retractable bearings.
 3. Sizes 14" through 20" round shall have a minimum 3/8" continuous damper rod axis with nylon grommets installed at damper sleeve penetrations
 4. Provide dampers, which shall include an extended threaded shaft that aligns with a sheet metal stand-off bracket (spot welded to the fitting) with the stand-off distance to be 2" to clear the thickness of any external duct wrap insulation. Coordinate stand-off dimensions with specified duct insulation

thickness (only when thicker than 2"). Damper handle and wing nut to be fastened at the outside of the stand-off bracket.

5. Provide premium optional balance dampers to include a 2" stand-off bracket, spot welded to the fitting, to include a 3/8" square shaft extended to the stand-off bracket, with U-bolt, nylon bushings, locking quadrant and handle.

G. Acceptable Manufacturers:

1. Flexmaster or equals by,
2. Crown Company Products,
3. Ductmate,
4. Hercules Industries.

2.3 FIRE, SMOKE, AND COMBINATION SMOKE-FIRE DAMPERS

- A. Contractor shall furnish and install fire, smoke, and combination smoke-fire dampers in air passages, openings, and ductwork wherever shown on the Drawings, and as required by the local authorities having jurisdiction. Installations shall be in accordance with all applicable NFPA standards and the SMACNA Duct Manual. All dampers shall carry the U.L. Label and shall be installed such as to conform to conditions under which the U.L. Label was granted. All dampers shall be constructed and tested in accordance with the latest edition of U.L. Safety Standards 555 or 555S, as applicable. Provide sleeves, typically 12" in length minimum, for all dampers as required for the installation conditions encountered.
- B. Provide customized assembly lengths for applications where the wall thickness or general construction penetrated by the fire/smoke damper assembly requires such. Review architectural plans to confirm these locations when the wall thicknesses appear to be thicker than normal on the mechanical plans.
- C. Fire dampers shall be constructed in accordance with the recommendations of the NFPA and shall be of metal gauges required by the class of separation in each case.
 1. Interlocking curtain blade type fire dampers carrying the Underwriters' Label will be acceptable, except at locations where an operating type damper is required to meet local requirements, to meet sequence of operations indicated in Temperature Control Specifications, Section 23 0900, or to meet the limited spaces available.
 2. Use Style "B" rectangular and style "CR" for round dampers such that blades are out of the air stream.
 3. For grille installations at fire rated partitions, use Style "B" thin line fire dampers or Style "G" integral sleeve type for grilles.
- D. Smoke dampers shall be designed for vertical or horizontal applications as encountered in accordance with NFPA 90A and meet the latest requirements of UL 555 S. Smoke dampers shall be installed in, or adjacent to, the smoke barrier; but in no case, more than 24 inches from the smoke barrier. Smoke dampers shall be a Ruskin Model SD35, 36, 37, or SDRS25 as applicable for the application. Frames shall be made of 16 gauge single piece galvanized steel hat shaped channel frames. Blades shall be 6" wide

galvanized steel and be the triple V-groove or air foil type. Provide stainless steel jamb seals, silicone edge type blade seals where required for the classification, stainless steel sleeve bearings and linkages concealed in the frame. Leakage Class shall be Class 1, 2, or 3, as required, to meet the requirements specified elsewhere herein. Provide compatible electric actuator on all dampers, factory installed.

- E. Combination fire-smoke dampers shall be Leakage Class 1 dampers with electric, manually resettable, fuse link operated by 120 volt electric actuator furnished with the damper. Fire-smoke dampers shall be Ruskin FSD-60, or equal, with minimum 16 gauge galvanized steel hat channel shaped frames. Fire-smoke dampers shall be increased in size to maintain a minimum of 90 percent free area of the ductwork size indicated on the Drawings thru each fire-smoke damper. Leakage shall be Class 1, 2, or 3, as required, to meet the requirements specified elsewhere herein. Provide compatible electric actuator on all dampers, factory installed.
- F. Insulated all metal access panels, secured with sash locks, shall be installed to service all fire, smoke, and combination smoke-fire dampers. Access panels shall be identified with "FIRE DAMPER", "SMOKE DAMPER", or "SMOKE-FIRE DAMPER" stenciled thereon in a visible or conspicuous location. Removable flexible duct shall not be permitted as a means of damper access. Access shall be direct and shall not be obstructed by turning vanes or other duct accessories.
- G. General Requirements:
 - 1. For "Ductmate" connections at fire, smoke, or combination smoke-fire dampers, do not use screw fasteners.
 - 2. Use four inch (4") draw band connections at round duct fire damper connections.
 - 3. Use blade dampers when the blade width exceeds 12 inches.
 - 4. Install vertical or horizontal mount dampers suitable for the application.
 - 5. Dampers shall be suitable for the maximum air system operating pressures expected to be encountered. Medium pressure ductwork is expected to operate at up to six inches (6") W.G.
 - 6. Use multi-section dampers where damper size openings are larger than single section maximum sizes.
 - 7. Fire, smoke and combination smoke-fire dampers shall be sized to provide for 100 percent of the ductwork size (minimum 95% free area) indicated on the Drawings through each damper.
 - 8. Provide 165 Deg. F. rated fusible links for fire dampers.
- H. Acceptable Manufacturers:
 - 1. Ruskin, or approved equals by:
 - 2. Greenheck, or
 - 3. Nailor, or
 - 4. Prefco, or
 - 5. National Controlled Air (N.C.A.), or

6. Air Balance, or
7. Pottorff.

2.4 FLEXIBLE CONNECTIONS

- A. Where ducts connect to fans, including roof exhausters, flexible connectors shall be made that are fire-resistant, (up to 200 Deg. F.), waterproof, mildew-resistant and essentially airtight, and shall weigh approximately thirty ounces (30 oz.) per square yard.
- B. There shall be a minimum of one-half inch (1/2") slack in these connections, and a minimum of two and one-half inches (2-1/2") distance between the edges of the ducts for a total of three inches (3"). There shall also be a minimum of one inch (1") of slack for each inch of external static pressure on the fan system for medium pressure systems.
- C. Acceptable Manufacturers:
 1. Vent Fabrics "Ventglas", or approved equals by:
 2. Duro-Dyne.

2.5 ACCESS DOORS

- A. Furnish and install hinged, low leakage access doors in ductwork or plenums to provide access to all fire, smoke and combination fire - smoke dampers, mixed air plenums, automatic dampers, coils, filters, and elsewhere as detailed on the Drawings.
- B. Where the ducts are insulated, the access doors shall be double skin doors with a minimum one inch (1") of insulation in the door. The insulation shall have a minimum R-value of 5.0. Increase the thickness of the insulation as needed to comply. Where the access door is installed in non-insulated ductwork the access door shall be unlined sheet metal of the same gauge thickness as the duct.
- C. In no case shall access doors be smaller than eight (8") by eight inches (8"). Access doors shall be sized to permit testing or servicing of duct mounted components, such as, for coil cleaning, installation of control devices, resetting of fusible links, filter replacement, etc., as applicable and suitable for the application.
- D. Where duct access doors are above a suspended, normally non-readily accessible ceiling, such as plaster, gypsum board or spline type ceilings, Contractor, under this Section of Specifications, shall be responsible for the proper location, and furnishing of, ceiling access doors, or panels, to make duct access doors easily accessed through the ceiling system. Ceiling access doors, or panels, shall be rated, where applicable, to match the fire rating of the ceiling system penetrated. Ceiling access doors, or panels, shall be installed under other Sections of these Specifications. Ceiling access doors, or

panels, shall be centered directly beneath duct access doors or immediately adjacent thereto when duct access is through the side of the duct.

- E. In rectangular grease exhaust ducts, install access doors every twenty feet (20') maximum, center to center, and at all 90 degree elbows, when the total developed length exceeds forty feet (40'). Install access doors at every other floor level for vertical grease exhaust duct risers.
- F. All access doors shall be fully double gasketed, door to frame and frame to duct, and include a sash type or compression latches for sizes under eighteen inches (18") by eighteen inches (18"). Use one (1) sash type latch per twelve inches (12") of height or width. Access doors 18" x 18" and larger shall have quarter turn handle latches. Provide one handle per 24" section, height or width, of door. As an example, provide two (2) handle type latches for a 48" tall access door.
- G. Provide a minimum of two (2) heavy loose pin hinges for each access door unless indicated otherwise herein. Piano style hinges will be an allowed substitute.
- H. Where the installation conditions prohibit suitable access with hinged access doors, then non-hinged access doors may be used in conjunction with a corrosion resistant cable or chain, of suitable length, attached to the access door and duct.
- I. For duct systems constructed to 2 inches W.G standards, or less, provide standard access doors meeting all requirements specified herein, which have a tested air leakage rating of less than 4.0 CFM at a test pressure of 2 inches W.G., and as manufactured by:
 - 1. Ventlok with hinges and No. 90 or No. 99 latches (less than 18" x 18"), or No. 100 or No. 140 latches (18" x 18" and larger), as applicable, or approved equals by:
 - 2. Ductmate, or
 - 3. Duro Dyne DDIAD-0806, or
 - 4. NCA Manufacturing ADH-T-1, or
 - 5. Pottorff HAD or CAD, or
 - 6. Nailor 08SH with HP Seal, or 0890, or
 - 7. Cesco Products HDG, or
 - 8. Ward Sandwich Style Access Doors, DSA or DDA, for round ductwork.
- J. For duct systems constructed over 2 inches W.G., up to 6 inches W.G. standards, provide high pressure low leakage access doors meeting all requirements specified herein, which have a tested air leakage rating of less than 1.0 CFM at a test pressure of 6.0 Inches W.G. and as manufactured by:
 - 1. Ventlok similar to that noted above, or their Twist-In Door (insulated), or approved equals by:
 - 2. Ductmate "Sandwich" (Rectangular ducts), or Ductmate "Metu" (Round ducts), or
 - 3. Ward Duct Connector Industries Type 'F' (Rectangular ducts) or Type 'R' (Round Ducts), or

4. Nailor 0820-1 or 0895, or
5. Pottorff OAD.

2.6 TURNING VANES

- A. Turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct.
- B. Turning vane front and back panels shall be securely locked together with adequate crimping to prevent twisting of vane. Vanes shall be capable of withstanding 250 pounds of tensile load when secured according to the manufacturer's instructions.
- C. Rails for mounting vanes shall have self-locking, friction fit tabs designed to facilitate proper alignment of vanes. Tab spacing shall be as specified in Figure 4-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible", Third Edition standard. Rail systems with non-compliant tab spacing shall not be accepted.
- D. Acoustical Turning Vanes shall be used in applications that require quiet operating systems. Mounting rails shall have friction insert tabs that align the vanes automatically. These shall only be required where designated on the Drawings.
- E. Vanes shall be either the two inch (2") or four inch (4") double wall type vanes depending on the size of the ductwork and shall be factory manufactured only.
- F. Approved Manufacturers:
 1. Ductmate Industries PRO-Rail Turning Vanes,
 2. Harper Double Wall turning vanes,
 3. Or pre-approved equals only.

2.7 GRILLES, REGISTERS, AND DIFFUSERS

- A. Grilles, registers, ceiling outlets, diffusers and other air devices shall be as scheduled on the Drawings and shall be suitable for the intended use.
- B. Provide air devices with sponge rubber or soft felt gaskets at flanges where the devices mate up to a ceiling or wall surface.
- C. If a manufacturer other than the one scheduled is used, the sizes shown on the Drawings shall be checked for performance, noise level or criteria, face velocity, throw, drop, pressure drop, air diffusion, etc., before the submittal is made. Selections shall meet the manufacturers' own published data for the above performance criteria. The throw shall be such that the terminal velocity will be not more than 50 FPM or less than 25 FPM at the point of penetrating the occupancy zone. The occupancy zone is defined as six feet (6') above the finished floor and six inches (6"), or farther, from the walls.

- D. Noise levels shall not exceed those published in current ASHRAE Standards and Guidelines for the type of space being served (N.C. level) or that scheduled.
- E. Locations of outlets on Drawings are approximate and shall be coordinated with other trades to make symmetrical patterns and shall be governed by the established pattern of the lighting fixtures, structure and Architectural Reflected Ceiling Plan (RCP). Air devices shall have margins, frames, and sizes to be compatible with the ceiling and wall systems installed. All color and finishes are subject to final approval by the Architect.
- F. Where called for on the schedule, grilles, registers, ceiling outlets, diffusers and other air devices shall be provided with deflecting devices and manual dampers.
- G. Where indicated on the Drawings, provide a fire rated blanket on the back side of steel ceiling mounted air devices (supply, return, exhaust, etc.).
- H. Where indicated on the Drawings, provide an insulation blanket on the back side (all surface area above the ceiling) of ceiling mounted supply air devices to prevent condensation. Blanket may be factory or field applied but shall be continuous and field applied insulation shall match the density and vapor barrier of the factory applied option.
- I. All air devices shall be the standard product of the manufacturer, subject to review by the Architect. Acceptable manufacturers are:
 - 1. Titus, or approved equals only by:
 - 2. Krueger.
 - 3. Nailor.
 - 4. Metal-Aire/Greenheck.
 - 5. Carnes.
 - 6. Price Industries.

2.8 AIR FILTERS

- A. Provide appropriately sized and number of air filters for each piece of individual air handling equipment to include, but not be limited to, the following:
 - 1. Indoor A/C unit Fan-Coil Units.
 - 2. Filter Return Air Grilles serving ducted return air systems, where scheduled.
 - 3. Elsewhere as required to protect air type heat exchangers, such as warm air furnaces, or coil surfaces, such as duct mounted direct expansion coils.
- B. Medium efficiency air filters shall generally be two inches (2") thick, unless indicated otherwise and shall be the pleated media, disposable type, listed by Underwriters Laboratories as Class 2, with the following features:

1. Air filters shall be rated in accordance with the most recent version of ASHRAE Standards 52.1 and 52.2, test methods as indicated herein, and shall conform to Section 7.4 of AHRI Standard 850.
2. Filter media enclosing frame shall be constructed of rigid, heavy duty, high wet-strength resistant, "beverage" board with diagonal support members on the air entering and air exiting sides. Expanded diamond grid media support, integral with frame, shall be chemically bonded to filter media at each pleat, to ensure pleat spacing and stability. Pleated media shall be bonded to the inside of the frame to eliminate air bypass.
3. Filter media shall be high performance, non-woven, reinforced cotton-poly, synthetic blend fabric formed in a V-shape.
4. Filters shall have the following performance data:

THICKNESS	SQUARE FEET MEDIA AREA TO ONE SQUARE FOOT FACE AREA	MINIMUM PLEATS PER LINEAL FOOT	INITIAL AIR RESISTANCE (INCHES W.G.)	RESISTANCE BASED ON AIR FLOW OF
One Inch (1")	2.4	16	0.25 (350 FPM)	1400 CFM
Two Inch (2")	4.3	15	0.28 (500 FPM)	1500 CFM
Four Inch (4")	6.9	11	0.27 (500 FPM)	1500 CFM

5. Filters shall be suitable for operation with varying velocities of up to 500 feet per minute (FPM) for 2" and 4" filters and 350 FPM for 1" filters.
 6. Filters shall have a minimum efficiency of 25% with an average arrestance of 90 to 92% minimum dust holding capacity which shall be no less than 170 grams as tested in accordance with ASHRAE Standard 52.1. Filters shall also have a MERV rating of 11 as tested in accordance with ASHRAE Standard 52.2-2007.
 7. Acceptable Manufacturers:
 - a. Camfil Farr, Inc., MERV 11, Model Aeropleat IV, or approved equals by:
 - b. Environmental Filter Corporation.
 - c. Eco-Air.
- C. All filters shall be standard sizes that are readily and locally available, in stock, through multiple over the counter sources without requiring special order. Standard acceptable sizes shall be 16" x 20" and 16" x 25".

2.9 ADHESIVES AND SEALANTS

- A. All adhesives and sealants used on this project must have a Volatile Organic Compound (VOC) content less than that listed in the current South Coast Air Quality Management District (SCAQMD) Rule 1168, and all sealants and fillers must meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51.

- B. All adhesives and sealants shall meet the most current Leadership in Energy and Environmental Design (LEED™) requirements.

2.10 FIBERGLASS DUCTBOARD

- A. Fiberglass duct board of any type is not allowed on this project without exception.

2.11 ELECTRONIC BALANCING DAMPERS

- A. Where balance dampers are to be located above a hard ceiling, or in any inaccessible location, the contractor shall use electronic balancing dampers controlled with an Electronic Balancing Damper Positioner (EBDP) which opens and closes the damper and provides a visual indication of the damper position with a LCD meter.
- B. Each Remote Damper Assembly shall consist of a commercial quality damper actuated by a 12V DC motor with position feedback, a plenum rated cable with RJ-25 connectors on each end, termination options to control the damper from either a plenum, wall or ceiling location, and a hand held damper positioner that provides DC voltage to open and close the damper while displaying the damper position with the LCD position indicator meter.
- C. Each damper shall be either a round, rectangular, or High Efficiency Takeoff type damper, as applicable to the installation. Round dampers shall consist of a 20 gauge galvanized steel shell and blade with ½" plated steel damper shafts, and 12V DC Motor with position feedback. Rectangular dampers shall consist of a 20 gauge aluminum frame and blade, stainless steel slide, 18 gauge galvanized steel mounting plate for slip in installation, and 12V DC motor with position feedback. High efficiency takeoff dampers shall consist of a galvanized steel takeoff with 20 gauge blade and ½" steel shafts, and 12V DC motor with position feedback. Dampers shall include oil impregnated bronze bushings. Damper actuators shall use less than 0.5 watts of power (20 mA), have a torque capability of 16 inch-pounds (maximum), and rotate the damper from 0 - 90 degrees in 12 seconds or less. Feedback shall occur via a proportional voltage signal. Provide low leakage damper blade seals.
- D. Electric Cables shall be plenum rated cable, have modular connectors and be available in lengths up to 1,000 feet. Length of individual cables shall be field verified to insure no field splicing of cables is required. One modular connector shall be attached to each motor and the other end shall include a RJ-25 modular connector that would be installed inside a plenum or at a wall or ceiling receptacle, to be coordinated with the architectural drawings (acceptable locations). Ceiling connections shall be the concealed type similar to Young Regulator Company (YRC) TP -301. Wall connections shall be the suitable for 1- 6 ports and be similar to YRC TP-Wall.

- E. The Positioner (EBDP) shall be used to control all remote electronic balance dampers installed on site by use of ceiling or wall mounted receptacles, a plenum connection or a combination of these options. The Positioner shall be self-contained and be a hand held device. Each positioner shall be provided with a high capacity long life lithium battery which shall be easily replaced in the field. Provide one (1) Positioner for each site or building to include one (1) spare battery for each positioner furnished. Positioner shall use a modular RJ-25 connector that plugs into the modular connector served by the 12V DC motor. The positioner battery shall drive the damper motor open and closed. The positioner shall also house the LCD display that provides precise damper position indication throughout the range of movement via a proportional voltage feedback signal from the motor.
- F. Acceptable Manufacturers:
1. Young Regulator.
 2. Greenheck.
 3. Metropolitan Air Technology (MAT).
 4. Or other approved equals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all ductwork and equipment as indicated on the Drawings in full accordance with these specifications including foundations, hangers, supports, etc.
- B. Seal all ductwork as specified, pressure test and repair leaks.
- C. Install one inch (1") wide by 18" long orange (brightly colored) plastic strip tape (no adhesives) at each manual air balance damper located for easy visibility from normal intended above ceiling access points to clearly identify location of these dampers.
- D. Install all duct mounted components in accordance with the manufacturer's recommendations.
- E. Should defects or installation deficiencies become apparent, or are observed, after the systems have been in operation, the deficient components shall be removed and replaced or reinforced as directed by the Owner's Representative.

3.2 CLEANING OF DUCT SYSTEMS

- A. Before the grilles or diffusers are installed, all fans and air conditioning units shall be operated and all debris and foreign matter shall be removed from the ducts.

- B. The air conditioning units shall be thoroughly cleaned, and the drain pans shall be thoroughly cleaned and flushed out with a hose; the filters shall be thoroughly cleaned and the grilles shall then be installed.
- C. Insure all duct openings are capped and sealed during construction when additions are not being made.

3.3 FILTERS

- A. No air moving equipment may be operated at any time without filters being fully installed in equipment.
- B. Provide a minimum of three (3) spare sets of two inch (2") thick, medium efficiency, pleated media filters for all air handling and fan coil units, as well as for filter return air grilles where scheduled, in addition to manufacturer furnished filters specified elsewhere herein. Where other sections of these specifications require one inch (1") or four inch (4") thick filters, or other types of filters, provide spare sets of matching thickness and type.
- C. Additionally replace filters during construction as directed by the Owner's Representative.
- D. Install one (1) new complete set of filters, as directed by the Test and Balance (TAB) Firm, just prior to performance of TAB work.
- E. Install one (1) new set of filters at "Substantial Completion" of the project.
- F. Where the minimum number of filter sets are not used for the aforementioned purposes, provide the left over filters to the Owner for maintenance stock.
- G. Document, in writing, when each filter change-out occurs.

END OF SECTION

SECTION 23 43 00

AUTO-CLEANING NEEDLEPOINT BIPOLAR IONIZATION SYSTEM

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other trades.

1.2 SYSTEM DESCRIPTION

- A. Scope of work shall include furnishing and installation of auto-cleaning needlepoint bipolar ionization system and accessories as indicated and specified herein.
- B. All items of equipment shall meet or exceed scheduled capacities and shall be provided in quantities indicated.

1.3 QUALITY ASSURANCE

- A. All work shall comply with the most recent edition, with amendments of the local Building Code, Mechanical Code, Plumbing Code, Fire Code, and all other state and local codes or ordinances.
- B. All auto-cleaning needlepoint bipolar ionization systems shall be Underwriters Laboratory (U.L.) listed and shall be listed for the specific installation application.
- C. All equipment installations shall be installed in accordance with the National Electrical Code (NEC).
- D. The manufacturer of each type of equipment specified herein shall have a minimum of five (5) years operating experience with the auto-cleaning needlepoint bipolar ionization system.

1.4 SUBMITTALS

- A. Indicate equipment, materials, quantities, sizes, installation details and any other descriptive literature necessary to fully evaluate submittals for compliance with these specifications.
- B. Provide power supply and control wiring diagrams suitable for use by an electrician and control wiring technician.

- C. Shop Drawings: Submit complete shop drawings in accordance with Division 1 and Section 23 0500.

1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Damaged, deteriorated, or wet materials shall be rejected and replaced.
- B. Take all measures necessary to protect equipment from damage or vandalism during construction. Any such damage discovered shall be cause for rejection of equipment, in which case the Contractor shall replace equipment at no cost to the Owner.

PART 2 - PRODUCTS

2.1 AUTO-CLEANING NEEDLEPOINT BIPOLAR IONIZATION SYSTEM

- A. Provide auto-cleaning needlepoint bipolar ionization system which shall be complete packaged units with controls and accessories as specified herein to meet scheduled capacities as indicated on the Drawings.
- B. For each new VRV/VRF indoor fan coil unit serving normally occupied areas (excludes ductless units except cassette unit serving the Fitness Room). Provide one (1) bipolar ionization system for each unit (capacity up to 4,800 CFM).
- C. Each unit shall be furnished with universal voltage input, in-line on/off switch, programmable auto-cleaning cycle, operation status LED, mounting magnets and replaceable carbon fiber brush emitters.
- D. Each unit temperature range shall be -20 Deg. F. to 200 Deg. F. and 0-100% humidity range.
- E. Each unit input voltage and amps shall be 24V AC/DC, 0.41A to 0.041A with 10 watts power consumption.
- F. Each unit total ion output shall be more than 400 million ions/CC.
- G. All rooftop units shall be provided with a field installed auto-cleaning needlepoint bipolar ionization system. The system shall be installed after the air filter and before the D/X coil.
- H. Each unit shall be design-certified by Underwriters Laboratories and be UL listed and meet the requirements of the NEC.
- I. Acceptable manufacturers:
 - 1. Global plasma solutions model GPS-FC48-AC.

PART 3 - EXECUTION

3.1 DELIVERY AND PROTECTION

- A. Deliver all equipment to each site as indicated in Division 1.
- B. All equipment shall be handled carefully to avoid damage and be protected from exposure to the weather and dirt. All equipment shall be examined upon delivery to the site and evidence of abuse, damage, or exposure to weather and dirt shall be grounds for refusal to accept individual pieces of equipment. Rejected items shall be replaced promptly at no cost to the Owner.
- C. Protect equipment during construction. Equipment damaged during construction prior to "Substantial Completion" shall be repaired or replaced at no cost to the Owner.

3.2 INSTALLATION

- A. Install and wire auto-cleaning needlepoint bipolar ionization system and field installed appurtenances in full accordance with the recommendations of the unit manufacturers and as indicated on the Drawings.
- B. Provide power and control wiring as specified herein and as indicated on the Drawings. Power shall be supplied from the control transformer serving the respective fan coil unit.
- C. Follow all national and local codes related to the wiring of auto-cleaning needlepoint bipolar ionization system.
- D. Verify correct installation and operation of each device installed.

END OF SECTION

SECTION 23 81 28

VARIABLE REFRIGERANT FLOW (VRF) AIR CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

- A. Comply with Division 1 - General Requirements and referenced documents.
- B. Comply with all other Division 23 Sections as applicable. Refer to other Divisions for coordination of work with other trades as required.

1.2 SYSTEM DESCRIPTION

- A. The Variable Refrigerant Flow System (VRF) shall be similar to the Daikin VRV IV heat pump system as the basis of design. The VRF system consists of an outdoor unit, multiple indoor units, and controls equipment provided by the manufacturer.
- B. Contractor shall connect all piping, refrigerant specialties, required controls, field installed accessories, appurtenances, insulation, hangers, supports, foundations, etc. to make a complete and operational system.
- C. Refer to Section 23 23 01, VRF Refrigerant Piping.

1.3 QUALITY ASSURANCE

- A. All equipment and materials shall be new and of the best quality complying with all standards specified herein.
- B. All wiring shall be in accordance with the latest version of the National Electrical Code (NEC).
- C. The units shall be listed by the Electrical Testing Laboratory and shall have the ETL label displayed on each unit.
- D. All equipment and materials shall be installed in a workmanlike manner by experienced mechanics and as recommended by the equipment manufacturer or as detailed.
- E. All products shall meet the most current version of the International Energy Conservation Code (IECC).
- F. All condensing units shall meet the Energy Star® guidelines for energy efficiency.
- G. Contractor Qualifications:

1. It is intended that the installing Contractor be trained and certified for refrigerant piping installations specifically for VRF heat pump systems, and can demonstrate considerable experience in such work over the last three to five (3-5) years. Such qualifications shall be the basis for acceptance of qualified contractors by the Owner and Architect/Engineer (A/E) to carry out this work under this project.
2. The following contractors have a demonstrated history with VRF technology and are approved for the installation of VRF systems for this project; and shall be limited to the following:
 - a. Encore Mechanical, LLC, Southlake, TX, Ph: (817) 416-2881
 - b. ACIS Solutions, McKinney, TX, Ph: (972) 562-6507
 - c. Dallas Mechanical Group, Dallas, TX, Ph: (972) 234-4822
 - d. NTD Mechanical, Garland, TX, Ph: (469) 323-0454
 - e. H&G Systems, Garland, TX, Ph: (214) 341-5486
3. Any Contractor not appearing on the approved list above that is interested in being considered to bid on this project shall submit qualified substitution qualifications to the Architect, in writing, no less than ten (10) days in advance of the Bid. Qualifications shall include:
 - a. The firm shall have three (3) references from completed VRF projects of similar size and system choice and provide proof for each project that the documented start-up and commissioning was completed and therefore bound the manufacturer's to their warranty and extended warranty coverage.
 - b. Provide a portfolio of VRF installations for the proposed Project Manager and Superintendent that they performed directly and proof of successful completion of manufacturer approved "Installation", "Start-up" and "Service" training.
 - c. All foreman/crew leaders that work on and oversee VRF installations shall provide proof of manufacturer training to include the "Installation" course for each type of system to be installed on this project.
 - d. VRF control installation and system start-up services shall be completed ONLY by a factory authorized agent. The manufacturer responsible for the control installation, start-up and/or for submitting the documents required for warranty, shall be identified within the Contractor's proposal.
 - e. Consideration of any Contractor by the Owner and A/E shall be based on the quality and experience of past (last 3-5 years) VRF installations, whose decision (Owner and A/E) shall be final.
 - f. Consideration may also be given to any approved VRF installing Contractor, including those listed, to be proposed as a sub-contractor for the VRF system only, under the Mechanical Contractor.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's descriptive literature and installation instructions and method for the configuration of equipment proposed, including wiring diagrams, piping connections, sizing and other descriptive literature necessary to evaluate the Submittals for compliance with specifications.
- B. Include matched combination ratings for condensing units and indoor coils to account for refrigerant line routing and length of run.
- C. Shop Drawings: Submit in accordance with Section 23 05 00.

1.5 PRODUCT HANDLING

- A. Deliver all equipment to the site where it shall be covered and protected. Material not properly protected and stored and which is damaged or defaced during construction shall be replaced at no cost to the Owner.
- B. Storage and protection of materials shall be in accordance with Section 23 05 00.

1.6 INSTALLATION, OPERATION, AND MAINTENANCE BROCHURES

- A. Furnish all installation manuals required by a qualified mechanical system installer for proper installation of equipment. Manuals shall be provided with equipment and be attached thereto.
- B. Complete bound Operating and Maintenance Brochures shall be submitted a minimum of 30 days prior to completion of construction.

PART 2 - PRODUCTS

2.1 OUTDOOR UNITS

- A. General:
 - 1. The condensing unit is designed specifically for use with its series components.
 - 2. The refrigeration circuit of the condensing unit shall consist of inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.
 - 3. High/Low pressure gas line, liquid and suction lines must be individually insulated between the condensing and indoor units.
 - 4. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
 - 5. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

6. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
7. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
8. Installing contractor to follow Equipment Manufacturer's recommended service clearances.

B. Unit Cabinet:

1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from galvanized steel and be finished with powder coat baked enamel paint.

C. Fan:

1. The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The condensing unit shall have configurable settings for intermittent fan operation to help minimize snow accumulation on fan blades when the system is off.
4. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.

D. Condenser Coil:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins shall be coated with an anti-corrosion hydrophilic blue coating as standard from factory with a salt spray test rating of 1000hr per ASTM B117 test standards.
5. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for a drain pan heater. The lower part of the coil shall be used for inverter cooling and be on or off during operation enhancing the defrost operation.
 - a. An alternate manufacturer must provide a drain pan heater to enable adequate defrosting of the unit in defrost operation.

E. Compressor:

1. The inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit.
 - a. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value.
 - b. Non –inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.
2. The compressor's motor shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
3. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
4. Oil separators shall be standard with the equipment together with an intelligent oil management system.
5. The compressor shall be mounted on vibration dampening rubber grommets to minimize the transmission of vibration, eliminating the standard need for external spring isolation.
6. In the event of compressor failure, the remaining compressors, if applicable, shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be manually activated to specifically address this condition for single module and manifold systems.
7. In the case of multiple condenser modules, combined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours. When connected to a central control system sequential start is activated for all systems.

F. Electrical:

1. The outdoor unit shall be capable of operation within voltage limits of +/- 10% rated voltage.
2. The outdoor unit shall be controlled by integral microprocessors.
3. The control circuit between the indoor units and the outdoor unit shall be 16/18 AWG, 2 wire, stranded, non-shielded and non-polarized daisy chain control wiring.

2.2 FOUR-WAY CEILING CASSETTE UNIT (FXFQ)

A. General:

1. Four-way ceiling cassette indoor units shall recess into the ceiling and mount flush.
2. Shall be designed for use with R-410A refrigerant.
3. Shall be installed with heat pump or simultaneous heating and cooling heat pump VRF systems of the same manufacturer.
4. The indoor unit shall communicate with the outdoor unit via 16/18 AWG, 2 wire, stranded, non-shielded and non-polarized daisy chain control wiring.
5. Shall be rigidly constructed using a decaweb base plate.
6. Installing contractor to follow Equipment Manufacturer's recommended service clearances.

B. Indoor Unit:

1. The indoor unit shall be factory assembled, wired and run tested.
2. The indoor unit shall be factory wired and piped with its own electronic expansion device, control circuit board, fan and motor.
3. The indoor unit shall have:
 - a. Self-diagnostic function
 - b. Auto restart function
4. Indoor unit refrigerant circuit shall be filled with a dry nitrogen gas charge from the factory.

C. Unit Cabinet:

1. The four-way ceiling cassette cabinet shall be designed to recess into the ceiling.
2. The cabinet panel shall have provisions for a field installed, pressurized and filtered outside air intake.
3. Branch ducting shall be allowed from cabinet following manufacturer recommendations.

D. Grille:

1. Four-way grille shall be fixed to bottom of the cabinet and allow two, three or four-way air flow.
2. Grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space.
3. The indoor unit vanes shall have 6 fixed positions.
4. The indoor unit vanes shall be capable of automatically swinging the vanes up and down for uniform air distribution. Vanes shall also be capable of being stopped at any position during swing operation.
5. The indoor unit shall have a setting in the heating or cooling mode that shall cycle the vanes up and down to evenly heat or cool the space.
6. Four-way ceiling cassette grille shall have integral sensor to read wireless handheld remote controller as standard from the factory.

E. Filter:

1. The return air shall be filtered by means of a washable long-life filter with mildew proof resin and antibacterial treatment.

2. Optional high efficiency disposable air filters shall be available.
3. Optional Self-Cleaning Filter Panel, which performs automatic filter cleaning up to once a day, with dust collection box that indicates when to be emptied.

F. Fan:

1. The indoor fan shall be an assembly with one turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced.
3. Motor shall have permanently lubricated bearings.
4. In cooling mode, the indoor fan shall have the following settings; Super Low, Low, Med, High, Power Cool, and Auto.
5. In heating mode, the indoor fan shall have the following settings; Super Low, Low, Med, High, and Auto.
6. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
7. Constant indoor unit fan speed VRF system will not be acceptable.
8. The indoor unit shall have DIP switches that can be set to provide optimum airflow based on ceiling height.

G. Coil:

1. The indoor unit coil shall be nonferrous with louvered fins on copper tubing for maximum efficiency.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. The coils shall be pressure tested at the factory.
4. A condensate drain pan shall be factory installed below the coil.
5. All refrigerant lines to the indoor units shall be field insulated.

H. Condensate Pump:

1. The unit shall include a factory installed condensate pump that will be able to raise drain water up to 24 inches above the ceiling cassette face.

I. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 Hz.
2. The indoor unit shall be capable of operation within voltage limits of +/-10% rated voltage.

J. Controls:

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over a 16/18 AWG, 2 wire, stranded, non-shielded and non-polarized daisy chain control wire.

2.3 DUCTED - MEDIUM STATIC (FSXQ)

A. General:

1. High static indoor unit shall mount fully concealed within the provided cabinet.
2. Shall be designed for use with R-410A refrigerant.
3. Shall be installed with heat pump or simultaneous heating and cooling heat pump VRF 16/18 AWG, 2 wire, stranded, non-shielded and non-polarized daisy chain control wiring. The indoor unit shall communicate with the outdoor unit a stranded two conductor, twisted pair, non-shielded 16 gage chain communication.
4. Installing contractor to follow Equipment Manufacturer's recommended service clearances.

B. Indoor Unit:

1. The indoor unit shall be factory assembled, wired and run tested.
2. The indoor unit shall be factory wired and piped with its own electronic expansion device, control circuit board, fan and motor.
3. The indoor unit shall have
 - a. Self-diagnostic function
 - b. Auto restart function
4. Indoor unit refrigerant circuit shall be filled with a dry nitrogen gas charge from the factory.

C. Unit Cabinet:

1. The cabinet shall house filters and serviceable components with supply and return grills.

D. Filter:

1. Return air shall be filtered with a factory supplied removable, washable filter.
2. Return filter box with MERV 13 filter shall be field provided and installed not to exceed external static pressure limitation of the high static ducted indoor unit.

E. Fan:

1. The indoor unit fan shall be no more than one assembly with two Sirocco fans direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced.
3. Motor shall have permanently lubricated bearings.
4. In cooling mode, the indoor fan shall have the following settings: Low, Med, and High.
5. In heating mode, the indoor fan shall have the following settings: Low, Med, and High.

F. Coil:

1. The indoor unit coil shall be nonferrous with louvered fins on copper tubing for maximum efficiency.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. The coils shall be pressure tested at the factory.
4. A condensate drain pan shall be factory installed below the coil.

5. All refrigerant lines to the indoor units shall be field insulated.

G. Condensate Pump:

1. The unit shall include a factory installed condensate pump that will be able to raise drain water 27.5 inches above the bottom of the indoor unit.

H. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 Hz.
2. The indoor unit shall be capable of operation within voltage limits of +/-10% rated voltage.

I. Controls:

1. Unit shall use controls provided by the manufacturer to perform all functions necessary to operate the system effectively and efficiently and communicate with the outdoor unit over 16/18 AWG, 2 wire, stranded, non-shielded and non-polarized daisy chain control wiring.

J. Access:

1. If access is required from the bottom, then secondary drain pans shall not be required.

K. Accessories Provided:

1. Remote “in-room” sensor
 - a. Wall mounted, hard wired remote sensor is for ceiling-embedded type fan coils. The sensor for detecting the temperature can be placed away from the indoor unit (branch wiring is included in the kit).
2. Each unit shall be able to communicate with other indoor units and the heat pump unit using a field supplied minimum of 18 AWG, 2 core stranded and shielded communication cable.
3. Unit controls shall be capable of operating the indoor unit using one of the following four (4) operating modes:
 - a. Heating mode.
 - b. Cooling mode.
 - c. Fan only mode.
 - d. Enhanced dehumidification mode.

2.4 FXAQ – WALL MOUNTED UNIT (FXAQ) Indoor Unit:

1. The Daikin indoor unit FXAQ shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The

remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart. The drain pipe can be fitted to from either left or right sides.

2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. Return air shall be through a resin net mold resistant filter.
5. The indoor units shall be equipped with a condensate pan.
6. The indoor units shall be equipped with a return air thermistor.
7. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
8. The voltage range will be 253 volts maximum and 187 volts minimum.

B. Unit Cabinet:

1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

C. Fan:

1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range 0.054 to 0.058 HP.
3. The airflow rate shall be available in high and low settings.
4. The fan motor shall be thermally protected.

D. Coil:

1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 2-row cross fin copper evaporator coil with 14 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1 1/16 inch outside diameter PVC.
5. A thermistor will be located on the liquid and gas line.
6. A condensate pan shall be located in the unit.

E. Electrical:

1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).

3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

F. Control:

1. The unit shall have controls provided by Daikin to perform input functions necessary to operate the system.
2. The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.
3. The unit shall be compatible with a Daikin Intelligent Touch Manager

2.5 CONTROLS

- A. The VRF system manufacturer shall provide all controls necessary for the system to function and operate efficiently. All operations and change-overs shall be an automatic process without input from the Owner.
- B. Thermostats shall meet the current International Energy Conservation Code requirements as a commercial A/C type thermostats.
- C. Microprocessor Controls:

2.6 ACCEPTABLE MANUFACTURERS

- A. Basis of Design Product; Subject to compliance with specified requirements, shall be the Daikin VRV IV variable flow VRF system as manufactured by Daikin.
- B. Alternate acceptable manufacturers include the following:
 1. LG Electronics
 2. Mitsubishi Corporation
- C. Consideration may be given to other qualified VRF manufacturers as an "approved equal".
 1. Such consideration shall be based on manufacturer that is equal to or greater than manufacturer named as the basis of design in all respects with regard to quality, characteristics, type, size, capacities, etc., as well as strength of local service and support representation.
 2. Manufacturer shall be required to meet all requirements in the drawings and specifications, and shall show evidence and references for multiple successful VRF system installations in this locality over the last 3-5 years, similar to systems under this project.
 3. Manufacturers desiring to be considered shall submit all technical and qualification submittals in strict accordance with the substitution procedures specified under Section 21 00 00.
 4. Acceptance or rejection of any proposed manufacturer will be determined solely by the Owner and A/E based on the above criteria, whose decision shall be final.

PART 3 - EXECUTION

3.1 DELIVERY AND PROTECTION

- A. Deliver all equipment to each site. All equipment shall be handled carefully to avoid damage and be protected from exposure to the weather and dirt. All equipment shall be examined upon delivery to the site and evidence of abuse, damage, or exposure to weather and dirt shall be grounds for refusal to accept individual pieces of equipment. Rejected items shall be replaced promptly at no cost.
- B. During construction, take all steps necessary to protect equipment from damage or vandalism. All damage or vandalism shall be repaired at no cost to the Owner.

3.2 AIR COOLED CONDENSING UNIT AND INDOOR CASSETTE INSTALLATION

- A. Install condensing units level on roof supports where shown with vibration pads beneath unit legs.
- B. Route refrigerant piping and make connections to DX coils as recommended by the unit manufacturer.
- C. Furnish and install all refrigerant piping specialties including, but not limited to, thermal expansion valves, sight glasses, and filter dryers.
- D. Charge all refrigerant piping systems and equipment to maintain a fully operating refrigerant and oil charge.
- E. Charge all refrigerant piping systems and equipment to maintain a fully operating refrigerant charge.
- F. Verify correct power and control wiring installation. Measure operating voltage and current, check proper rotation of motors, and verify correct settings of safety devices and controls.
- G. Install new filters as specified in other sections of these specifications. Refer to Section 23 30 00.

3.3 REFRIGERATION PIPING

- A. Piping shall be Type "K" copper, ACR cleaned and capped. All fittings shall be long radius and shall be cleaned and de-greased before use. Use high purity dry nitrogen only.
- B. Refer to Section 23 23 01, VRF Refrigerant Piping.

3.4 OPERATING PROCEDURES AND REQUIREMENTS

- A. Three (3) copies of the operating and service instructions, in illustrated and bound form, shall be furnished by the manufacturer.
- B. The manufacturer of each item of equipment shall provide complete power and wiring diagrams to the Electrical and Control Systems installers, respectively. Drawings shall show all required external wiring and arrangements of electrical connections.

3.5 WARRANTY

- A. Transfer all Warranties to Owner for a full one (1) year period after the A/C systems are put into sustained operation to obtain building cooling effect for the benefit of occupancy by the Owner, Substantial Completion.
- B. Transfer any and all other warranties as applicable over to the Owner at the completion of construction, Substantial Completion, including extended four (4) year compressor warranties, as applicable, on refrigeration equipment.

END OF SECTION

SECTION 26 00 00

ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Division and all Electrical sections contained hereinafter are subject to the Contract Documents of Division 1 whether attached or not, the various Divisions of the General Construction specifications and Division 23 of the Construction specifications and respective plans.
- B. All drawings, material in other Divisions of these specifications, addenda, and other pertinent documents are considered to be a part of the technical requirements of this Division of the specifications insofar as they are applicable.
- C. The material contained in this section shall be applicable to other sections of the specifications under this Division.

1.2 DEFINITIONS

- A. The following definitions shall apply to all sections of this Division:
 - 1. "Owner" shall mean the Owner or his designated representative.

1.3 SCOPE OF WORK

- A. This Division and all electrical sections of the specifications include all labor and material to complete all electrical systems as specified or shown on the Drawings.
- B. All work shown and specified shall be completely installed and connected in a workmanlike manner by mechanics properly qualified to perform the work required. All work shall be left in a satisfactory operating condition as determined by the Owner.
- C. Provide all services and perform all operations required in connection with or properly incidental to the construction of complete and fully operating systems with all accessories as herein specified or shown on the Drawings.

1.4 GENERAL

- A. The accompanying plans show diagrammatically the location of the various light fixtures, devices, conduits and equipment items, and methods of connecting and controlling them. It is not intended to show every connection in detail or all fittings required for a complete system. The Contractor shall carefully lay out his work at the

site to conform to the conditions, to avoid obstructions and provide proper routing of raceways. Exact locations of light fixtures, devices, equipment, and connections thereto shall be determined by reference to the accompanying Plans, etc., by field measurement at the project, and in cooperation with other Contractors and Sub-Contractors, and in all cases shall be subject to the approval of the Owner. Minor relocations necessitated by the conditions at the site or directed by the Owner shall be made without any additional cost to the Owner.

- B. These specifications and the accompanying drawings are intended to describe and illustrate systems which will not interfere with the structures, which will fit into available spaces, and which will insure complete and satisfactorily operating installations. The Contractor shall be responsible for the proper fittings of his material and apparatus into the building and shall prepare installation drawings for all critical areas illustrating the installation of his work as related to the work of all other trades. Interferences with other trades or with the building structures shall be corrected by the Contractor before the work proceeds. Should any changes become necessary due to failure to comply with these stipulations, the Contractor shall make such necessary changes at his own expense.
- C. All work shall be run parallel or perpendicular to the lines of the building unless otherwise noted on the Drawings.
- D. It is the intent of the Contract Documents to provide an installation complete in every respect. In the event that additional details or special construction may be required for work indicated or specified in this section or work specified in other sections, it shall be the responsibility of the Contractor to provide those details or special construction as well as to provide material and equipment usually furnished with such systems or required to complete the installation.
- E. The Contractor, by submitting a bid on this work, sets forth that he has the necessary technical training and ability and that he will install his work in a satisfactory manner which is up to the best standards of the trade, complete and in good working order. If any of the requirements of the Drawings and Specifications are impossible to perform, or if the installation when made in accordance with such requirements will not perform satisfactorily, he shall report such occurrences to the Owner promptly after discovery of the discrepancy.
- F. No extra compensation will be allowed for extra work or changes caused by failure to comply with the above requirements.

1.5 INSPECTION OF THE SITE

- A. The Contractor shall visit the site, verifying all existing items indicated on the Drawings or specified, and familiarize himself with the existing work conditions, hazards, grades, actual formations, soil, conditions, and local requirements. The submission of bids shall be deemed evidence of such visit.
- B. All proposals shall take these existing conditions into consideration, and the lack of specific information on the Drawings shall not relieve the Contractor of any responsibility.
- C. All site visits shall be coordinated and scheduled with the Owner.

1.6 CUTTING AND PATCHING

- A. When cutting or patching becomes necessary to permit the installation of any work under this contract, or should it become necessary to repair any defects that may appear in patching up to the expiration of the guarantee, such cutting shall be done under the supervision of the Architect by the trade or Contractor whose work is to be disturbed. After the necessary work has been completed, damage shall be repaired by the Contractor or trade whose work has been disturbed. The cost of all such cutting and patching shall be paid by the Contractor requiring it to be done.
 - 1. Refer to Division 1 requirements.
- B. The Contractor shall do all necessary cutting and drilling of present walls, floors, ceilings, etc. for the installation of new work or for modifications to the existing work, but no structural work shall be cut unless specifically approved by the Architect. Patching and painting of services as required shall be by the General Contractor unless specified otherwise hereinafter.
- C. Locations of the various existing services, walls, and equipment to be altered, removed or connected to have been taken from plans of the existing building and other substantially reliable sources and are offered as a general guide only, without guarantee as to their accuracy. This Contractor shall examine the site and shall verify to his own satisfaction the location of all existing work and shall adequately inform himself as to their relation to and effect on the work before entering into a contract. Submission of a bid shall constitute evidence that the submitting Contractor has inspected the site of the proposed work.
- D. The Contractor shall examine the existing building and plans for the new work and note the sizes of the openings available and shall be responsible for any cutting, patching, and alterations required to place new equipment in the building.

- E. Where walls, acoustical tile, suspended ceilings, etc., not scheduled to be re-worked or re-finished under the general contract are damaged during installation of new raceways, or other work, etc., such walls, tiles, etc., shall be replaced by the General Contractor at the expense of the Contractor.
- F. All damage done to the existing equipment, services, etc., incurred in the execution of this contract shall be repaired and restored to its original conditions by the Contractor.
- G. Holes through concrete shall be drilled with "Mole", or "Core-It", or equal diamond point hole saw.

1.7 DEMOLITION OF EXISTING EQUIPMENT

- A. Certain types of equipment will be retained by the Owner. The Owner will provide a list of all such salvage items. Before removal of any equipment, contact the Architect, who will determine the disposition. Equipment designated to be salvaged and remain the property of the Owner shall be carefully removed to prevent damage and delivered to a location on the site as directed by the Architect. Any equipment not retained by the Owner shall become the property of the Contractor and shall be removed from the premises.
- B. The Contractor shall visit the site and verify all outlets, devices, wall switches, light fixtures, etc., that are to be removed due to remodeling work and building additions.
- C. The attendant raceways, hangers, wiring, foundations, etc., of those items of existing equipment to be removed and not intended for reuse, shall also be removed in their entirety. No raceways, hangers, etc., shall be abandoned in place except those raceways concealed in existing walls or buried below grade.

1.8 CODE REQUIREMENTS

- A. All work shall comply with the provisions of these specifications, as illustrated on the accompanying drawings, or as directed by the Architect, and shall satisfy all applicable local codes, ordinances, or regulations of the governing bodies, and all authorities having jurisdiction over the work, or services thereto. In all cases where alterations to, or deviations from, the drawings and specifications are required by the authority having jurisdiction, report the same in writing to the Architect and secure his approval before proceeding. Upon completion of the work, furnish a statement from the inspecting authority stating that the installation has been accepted and approved. Provide complete utility service connections as directed, and submit, as required, all necessary drawings; secure all permits and inspections necessary in connection with the work, and pay all legal fees on account thereof. In the absence of other applicable local codes acceptable to the Architect, the National Electrical Code shall apply to this work.

1.9 RECORD DRAWINGS

- A. The Contractor shall, during the execution of the work, maintain a complete set of drawings upon which all locations of equipment, panels, and all deviations and/or changes in the work shall be recorded. All underground and overhead utilities provided under, or affected by, work of this Division shall be accurately located by dimensions. These "Record" drawings shall be delivered to the Architect in good condition upon the completion and acceptance of the work and before final payment is made.

- 1. Refer to Division 1 requirements.

1.10 RECORDS AND INSTRUCTIONS FOR OWNER

- A. The Contractor shall accumulate, during the project's progress, the following sets, prepared in neat brochures or packet folders and turned over to the Architect for checking and subsequent delivery to the Owner:
 - 1. All warranties and guarantees and manufacturer's directions on equipment and material covered by the Contractor.
 - 2. Approved equipment brochures, wiring diagrams and control diagrams.
 - 3. Copies of reviewed Shop Drawings.
 - 4. Operating instructions for all systems. Operating instructions shall include recommended maintenance procedures.
 - 5. Any and all other data and drawings required during construction.
 - 6. Repair parts lists of all major items and equipment including name, address, and telephone number of local supplier or agent.
- B. All of the above data shall be submitted to the Architect for review at such time as the Contractor makes application for final payment, but in no case less than two weeks before final observation.
- C. The Contractor shall also give not less than two (2) days of operating instructions, during the adjustment and testing period, to the Owner's operating personnel in order to familiarize them with the proper care and operation of the equipment. The written operating instructions referred to in above paragraphs shall be used as a basis for this on-the-job instruction.

- 1. Refer to Division 1 requirements.

1.11 SHOP DRAWINGS AND SUBMITTALS

- A. The Contractor shall submit, to the Architect, shop drawings and catalog data on all equipment and materials designated on the Drawings and specified herein.
- B. The submittal will be reviewed for compliance with general requirements of design and arrangement only; it is not a contract document and acknowledgement of compliance does not relieve the Contractor from responsibility for performance of the work in

compliance with all provisions and requirements of the Contract Documents. Job measurements and the coordination of all the dimensions for proper fit of all parts of the work and performance of all equipment supplies to meet specification requirements are and remain specific responsibilities of the Contractor.

- C. Shop Drawings shall be furnished by the Contractor for the work involved after receiving approval on the make and type of material and in sufficient time so that no delay or changes will be caused. This is done in order to facilitate progress on the job, and failure on the part of the Contractor to comply shall render him liable to stand the expense of any and all delays, changes in construction, etc., occasioned by his failure to provide the necessary detailed drawings. Also, if the Contractor fails to comply with this provision, the Architect reserves the right to go directly to the manufacturer he selects and secure any details he might deem necessary, and should there be any charges in connection with this, they shall be borne by the Contractor.
- D. The Shop Drawings submitted shall not consist of manufacturers' catalogues or tear sheet therefrom that contain no indication of the exact item offered. Rather, the submission on individual items shall designate the exact item offered.
- E. Shop Drawings submitted without indicating markings or Contractor's stamp shall not be reviewed and will be returned to the Contractor for correction of such discrepancies.
- F. The Shop Drawings are not intended to cover detailed quantitative lists of electrical specialties, and similar items, as the plans and specifications illustrate and describe those items, and it is the Contractor's responsibility to procure the proper sizes and quantities required to comply with the established requirements.
- G. Any Shop Drawings prepared to illustrate how equipment can be fitted into available spaces will be examined under the assumption that the Contractor has verified all the conditions, and obtained any approval thereon shall not relieve the Contractor of responsibility in the event the material cannot be installed as shown on those Drawings.
- H. Various material submissions of such as raceways, switches, panelboards, and related items shall be assembled in brochures or in other suitable package form and shall not be submitted in a multiplicity of loose sheets.
- I. Each Contractor shall process his submitted data to insure that it conforms to the requirements of the plans and specifications and that there are no omissions, errors or duplications.
- J. Shop Drawings shall be accompanied by certification from this Contractor that Shop Drawings have been checked by him for compliance with Contract Drawings.
- K. Samples of various products or mock-ups of particular details or systems may be required by various sections of this Specification.

- L. Refer to Division 1 requirements.

1.12 PENETRATIONS THROUGH FIRE-RATED ASSEMBLIES

- A. Seal voids around ducts and pipes penetrating fire-rated assemblies and partitions using fire-stopping materials and methods in accordance with provisions in Division 1.

1.13 CONNECTION OF EQUIPMENT FURNISHED BY OTHERS

- A. All equipment furnished under other Divisions of the specification requiring service connections shall be connected by this Contractor. Materials and labor required for the connection of this equipment shall be furnished under Division 26. The respective supplier shall furnish proper roughing-in diagrams for the installation of these items. All items shall be roughed-in and connected in strict accordance therewith. All equipment requiring connection may not be specified herein, but may be included in other Division documents. This Contractor shall ascertain for himself all equipment so specified is included as part of his work.
- B. Refer to Section 26 05 23.

1.14 DRAWINGS

- A. The drawings show diagrammatically the locations of the various conduits, fixtures, and equipment, and the method of connecting and controlling them. It is not intended to show every connection in detail and all fittings required for a complete system. The systems shall include, but are not limited to, the items shown on the drawings. Exact locations of these items shall be determined by reference to the general plans and measurements at the building and in cooperation with other trades and, in all cases, shall be subject to the approval of the Architect. The Architect reserves the right to make any reasonable change in the location of any of this work without additional cost to the Owner.
- B. Should any changes be deemed necessary in items shown on the contract drawings, the shop drawings, descriptions, and the reason for the proposed changes shall be submitted to the Architect for approval.
- C. Exceptions and inconsistencies in plans and specifications shall be brought to the Architect's attention before bids are submitted; otherwise, the Contractor shall be responsible for the cost of any and all changes and additions that may be necessary to accommodate his particular apparatus.
- D. Lay out all work maintaining all lines, grades, and dimensions according to these drawings with due consideration for other trades and verify all dimensions at the site prior to any fabrication or installation; should any conflict develop or installation be

impractical, the Architect shall be notified before any installation or fabrication and the existing conditions shall be investigated and proper changes effected without any additional cost.

- E. Titles of Sections and Paragraphs in these specifications are introduced merely for convenience and are not to be construed as a correct or complete segregation or tabulation of the various units of material and/or work. The Architect does not assume any responsibility, either direct or implied, for omissions or duplications by the Contractor due to real or alleged error in the arrangement of matter in the Contract Documents.

1.15 COOPERATION

- A. All work under these specifications shall be accomplished in conjunction with other trades on this project in a manner which will allow each trade adequate time at the proper stage of construction to fulfill his work.
- B. Maintaining contact and being familiar with the progress of the general construction and the timely installation of sleeves and inserts, etc., before concrete is placed shall be the responsibility of this trade as will the installation of the required systems in their several stages, at the proper time to expedite this contract and avoid unnecessary delays in the progress of other contracts.
- C. Should any question arise between trades as to the placing of lines, ducts, conduits, or equipment, or should it appear desirable to remove any general construction which would affect the appearance or strength of the structure, reference shall be made to the Architect for instructions.

1.16 MATERIALS AND EQUIPMENT

- A. All materials purchased for this Project shall be new.
- B. Where specified product is not manufactured, manufacturer's current product meeting specification shall be substituted, subject to written approval of Engineer.
- C. Space allocations in electrical spaces are based on equipment scheduled in each case. Should the Contractor offer equipment of another make, he shall verify that such equipment will fit in the spaces allowed.
- D. Manufacturers' names are listed herein to establish a standard. The products of other manufacturers will be acceptable; if, in the opinion of the Architect, the substitute material is of a quality as good or better than the material specified, and will serve with equal efficiency and dependability, the purpose for which the items specified were intended.

- E. It is fully the Contractor's responsibility to assemble and submit sufficient technical information to fully illustrate that the material or equipment proposed for substitution is equal or superior as the Architect or his Engineer is under no obligation to perform the service for the Contractor. The proposal shall be accompanied by manufacturers' engineering data, specification sheet, and a sample, if practical or if requested. In no event shall a proposal for substitution be cause for delay of work.
- F. Should a substitution be accepted under the above provisions, and should the substitution prove defective or otherwise unsatisfactory for the intended service, within the warranty period, the Contractor shall replace the substitution with the equipment or material specified, and on which the specifications required him to base his proposal.

1.17 STORAGE AND PROTECTION OF MATERIALS

- A. The Contractor shall provide his own storage space for protection and storage of his materials and assume complete responsibility for all losses due to any cause whatsoever. All storage shall be within the property lines of the building site, or as directed by the Owner's representative. In no case shall storage interfere with traffic conditions in any public or project thoroughfare.
- B. All work and material shall be protected at all times. This Contractor shall make good any damage caused, either directly or indirectly, by his workmen. He shall be responsible for safe handling of all electrical equipment and shall replace, without charge, all items damaged prior to acceptance by the Owner.

1.18 FOUNDATIONS

- A. Provide bases and foundations for all equipment specified or shown, unless specifically noted to the contrary. Foundations are generally to be built in compliance with the equipment manufacturer's shop drawings which have been approved by the Architect, or as directed by the Architect. Vibration or noise created in any part of the building by the operation of any equipment furnished or installed under this portion of the work will be objectionable. Take all precautions against same by isolating the various items of equipment from the building's structure, and by such other means as may be necessary to eliminate all excessive vibration and objectionable noise produced by any equipment installed; install all foundations, supports, etc., for raceway system and equipment with this end in view.

1.19 EXCAVATION AND BACKFILLING

- A. The Contractor shall do all necessary excavating and backfilling for the installation of his work. Trenches for underground conduits shall be excavated to required depths with bell holes provided as necessary to insure uniform bearing. Care shall be taken

not to excavate below depth, and any excavation below depth shall be refilled with sand or gravel firmly compacted. Where rock or hard objects are encountered, they shall be excavated to a grade six inches (6") below the lowermost part of the conduit and refilled to grade as specified. After the conduit has been installed and approved, the trenches shall be backfilled to grade with approved materials, well tamped or puddled compactly in place. Where streets, sidewalks, etc., are disturbed, cut, or damaged by this work, the expense of repairing same in a manner approved by the Architect shall be a part of this contract.

- B. The Contractor shall bear sole responsibility for design and execution of acceptable trenching and shoring procedures, in accordance with State of Texas Regulations. On trench excavations in excess of five feet in depth, contractor shall pay a qualified engineer to prepare detailed plans and specifications directing Contractor in the safe execution of trenching and shoring. It is understood that trench safety systems constitute a means and method of construction for which the Architect, Engineer, and Owner are not responsible. Accordingly, such documents when prepared, shall be separately issued by Contractor's Consultant, independent or project Contract Documents.

1.20 SCHEDULE OF WORK

- A. The work under the various sections must be expedited and close coordination will be required in execution of the work. The various Contractors shall perform their work at such times as directed so as to insure meeting scheduled completion dates, and to avoid delaying any other Contractor. The Architect will set up completion dates, schedule the times of work in the various areas involved, etc. This Contractor shall cooperate in establishing these times and locations and shall process his work so as to insure the proper execution of it.

1.21 CONTINUATION OF SERVICES

- A. The Contractor shall realize that the existing building must continue in operation during the construction period, except as the Architect and the Owner may direct otherwise.
- B. Under no conditions shall any work be done in the present building that would interfere with its natural use during the normal hours of occupancy, unless special permission is granted by the Owner. This is particularly applicable where new connections are to be made to present services or items of equipment in the building or where present equipment items in the building are to be relocated or modified in any way.

- C. Existing utility systems shall continue to function with a minimum of interruptions in service. This Contractor shall install any temporary lines, connections, etc., required to place and maintain the electrical systems in operation unless otherwise directed by the Architect.
- D. Arrange for and provide temporary electric and telephone services to the building where new construction conflicts with existing utility locations.

1.22 COMMISSIONING OF EQUIPMENT AND SYSTEMS

- A. The Contractor shall provide qualified personnel, as requested by the Owner and Architect, to assist in all on-site testing and commissioning of all equipment.

1.23 CLEANING UP

- A. The Contractor shall be responsible for cleaning up his work as specified in the General Requirements of these Specifications.

1.24 FINAL OBSERVATION

- A. Schedule: Upon completion of the Contract, there shall be a final observation of the completed installation. Prior to this observation, all work under this Division shall have been completed, tested, and balanced and adjusted in final operating condition and the test report shall have been submitted to and approved by the Owner.
- B. Qualified personnel representing the Contractor must be present during final observation to demonstrate the systems and prove the performance of the equipment.

1.25 CERTIFICATIONS

- A. Before receiving final payment, the Contractor shall certify that all equipment furnished and all work done is in compliance with all applicable codes mentioned in these Specifications.
- B. Furnish, at the completion of the job, a final Inspection Certificate from the local inspecting authority.

1.26 GUARANTEE

- A. The guarantee provision of this specification requires prompt replacement of all defective workmanship and materials occurring within one year of final job acceptance. This includes all work required to remove and replace the defective item and to make all necessary adjustments to restore the entire installation to its original specified operating condition and finish at the time of acceptance. The Contractor shall also guarantee that the performance of all equipment furnished and/or installed under this

Division of the specifications shall be at least equal to the performance as called for in the specifications and as stated in the equipment submittals. Should there be indication that the equipment and installation is not producing the intended conditions, the Contractor shall make further tests as the Engineer may direct to demonstrate that the equipment installed meets the specifications. If there is indication that the equipment does not meet the specifications, the Contractor shall, at his expense, institute a program to demonstrate the adequacy of the installation. This program shall include all necessary testing and testing equipment. Should the Contractor not have the equipment or technical skill to perform the tests, it shall be his responsibility to provide recognized experts to perform the tests and shall provide certified laboratory tests, certified factory reports and work sheets, or other certified data to support results of any tests required.

- B. Refer to Division 1 requirements.

PART 2 - PRODUCTS

NOT USED

PART 3 - INSTALLATION

3.1 DEVICE MOUNTING REQUIREMENTS

- A. Mounting heights listed in Drawings shall be defined as measured from the centerline of the device or outlet box to finished floor elevation. Unless specifically noted otherwise on the Drawings. Device heights shall be in accordance with the Texas Accessibility Standards or the Americans with Disabilities Act.
- B. Where devices are grouped together, they shall be mounted at the same height.
- C. Coordinate all mounting dimensions with Owner's requirements and coordinate with architectural elevations and details.

3.2 HOUSEKEEPING PADS

- A. Provide 4 inch thick concrete housekeeping pad with 6 x 6 wire mesh and same cure strength as adjacent floor for all floor-mounted electrical equipment unless otherwise indicated on the Drawings. Provide dowel connections to floor if pad is not part of continuous floor pour.
 - 1. Provide inserts for anchor bolts as required for each floor-mounted piece of electrical equipment.
 - 2. Provide 3/4 inch chamfered edge at all exposed edges.
- B. Minimum pad dimensions shall be 6 inches greater than dimensions, including all protrusions, of equipment to be installed.

1. Free-standing equipment: Center equipment on housekeeping pad.
2. Equipment anchored to wall: Center equipment side-to-side on housekeeping pad and reduce pad front-to-back dimension by 3 inches.

END OF SECTION

SECTION 26 05 01

ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1- General Requirements and related documents.
- B. All sections of this Specification.

1.2 DESCRIPTION

- A. Contractor shall remove several items of materials and equipment under this section of the specifications. Equipment and materials to be removed shall be as indicated and noted on the Drawings and as required to facilitate the new installations.
- B. Provide labor, materials, equipment, tools and services as required to complete the demolition work indicated.
- C. Refer to Division 1 for "Schedule of Work".

1.3 DISRUPTION OF EXISTING FUNCTIONS

- A. Under no conditions shall any work be done in the present building that would interfere with its natural or intended use unless special permission is granted by the Owner.
- B. Disruptions: Maintain existing lighting, power, telephone, and other systems, and maintain existing functions in service, except for scheduled disruptions as allowed in Division 01, "General Conditions".
- C. Provide all temporary connections as necessary to facilitate the phasing of construction.

1.4 SALVAGE, DEMOLITION, AND RELOCATION

- A. It shall be the responsibility of the Contractor to remove and store those items of existing equipment as indicated on the Drawings to be removed. All items of equipment or fixtures removed shall be protected from damage insofar as is practical.
- B. These items shall be stored on site for a minimum of two (2) weeks unless indicated otherwise by the Owner's representative to allow for inspection by the Owner. Deliver, all items tagged to be retained by the Owner to a designated storage location on site or to the Owner's designated Service Center or Warehouse. All items not retained by the

Owner shall be removed from the site by the Contractor at no additional cost to the Owner.

- C. The attendant conduit, hangers, foundations, etc., of those items of existing equipment to be removed, shall also be removed in their entirety. No hangers, etc., shall be abandoned in place.

D. Relocations:

1. Repair and restore to good functional condition materials and items scheduled for relocation and/or reuse and which are damaged during dismantling or reassembly operations.
2. New materials and items of like design and quality may be substituted for materials and items indicated to be relocated, in lieu of relocation, upon approval of shop drawings, product data and samples.
3. Remove carefully, in reverse to original assembly or placement, items which are to be relocated.
4. Protect items until relocation is complete.
5. Clean and repair and provide new materials, fittings, and appurtenances required to complete the relocation and to restore to good operative order.
6. Perform the relocation work in accordance with pertinent sections of the specifications, utilizing skilled workers.
7. Refer to Drawings for specific requirements of temporary services and relocated equipment and fixtures.
8. Coordinate with the General Contractor repairs required to bring finishes back to their original conditions after demolition and or installation of new equipment.

1.5 CLEAN UP

- A. Remove all debris, rubbish, and materials resulting from cutting, demolition, or patching operations from the work area on a daily basis.
- B. Transport materials and legally dispose of off-site.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide materials and equipment for patching and extending work as specified in individual sections or as indicated on the Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Field Conditions: Demolition Drawings are based on non-invasive field observations and existing record documents. Report discrepancies in location, dimensions or quantity to Owner and Architect prior to disturbing existing installation.
- B. Abandoned Wiring: Verify that abandoned wiring and equipment serve only facilities scheduled for demolition.
- C. Existing Conditions: Commencing demolition means Contractor accepts existing conditions.

3.2 PREPARATION

- A. Demolition: Disconnect electrical systems in walls, floors, ceilings and equipment scheduled for removal.
- B. Project Coordination: Coordinate utility service outages with utility companies and schedule work with Facility management and Owner.
- C. Temporary Wiring: Provide temporary wiring and connections as necessary to maintain existing systems in service during construction.
- D. Schedule installation of temporary wiring and connections to eliminate hazard to installing personnel.
 - 1. When work must be performed on energized circuits or equipment, use qualified personnel experienced in such operations.
 - 2. Submit "hot work" policy information to Architect for review prior to performing work on any energized circuits.
- E. Electrical Service: Maintain existing system in operation until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission, in writing, from Owner prior to partially or completely disabling system. Minimize outage duration. Make temporary connections as necessary to maintain service to areas unaffected by the scope of Work.
- F. Telephone Service: Maintain existing system in operation until new system is complete and has been accepted. Disable system only to make switchovers and connections. Obtain permission, in writing, from Owner, and notify the utility company, prior to partially or completely disabling system. Minimize outage duration. Make temporary connections as necessary to maintain service to areas unaffected by the scope of Work.
- G. Special Systems: Maintain existing systems in operation until new systems are complete and have been accepted. Disable systems only to make switchovers and

connections. Obtain permission, in writing, from Owner prior to partially or completely disabling systems. Minimize outage duration. Make temporary connections as necessary to maintain service to areas unaffected by the scope of Work.

1. The following systems will be affected by the scope of Work:
 - a. Fire Alarm System
 - b. Public Address System
 - c. Security System
 - d. Data System

3.3 DEMOLITION AND EXTENSION OF EXISTING WORK

- A. General: Demolish and extend existing work as indicated or described in the Drawings and Specifications.
 1. Lighting fixtures and electrical distribution equipment shall be salvaged for possible re-installation as directed by the Owner and Architect.
- B. Wiring: Remove abandoned wiring and cables to source of supply or termination.
- C. Raceways:
 1. Remove exposed abandoned conduits and raceways, including abandoned conduits and raceways above accessible ceilings.
 2. Conduits and raceways concealed in existing construction to remain shall be abandoned in place. Cut conduits and raceways such that finished surfaces can be patched smooth.
- D. Wiring Devices: Remove abandoned wiring devices. Provide blank device plate for outlet box not being removed.
- E. Electrical Distribution Equipment: Disconnect and remove abandoned panelboards and electrical distribution equipment.
- F. Lighting Fixtures: Disconnect and remove abandoned lighting fixtures, including brackets stems, hangers and other accessories not indicated to be re-used.
- G. Existing Installations to Remain: Maintain access to existing electrical installations which remain active.
- H. Modify installation or provide access panel as required.
- I. Extension of existing circuits: Extend existing installations as required to maintain service to items to remain using materials and methods, as specified that are compatible with original installation.
- J. Adjacent Construction: Repair adjacent construction and finishes damaged during demolition and extension work.

- K. Dispose of hazardous materials, such as fluorescent and H.I.D. lamps and PCB's in lamp ballasts, in accordance with all Local, State and Federal ordinances and regulations.

3.4 SALVAGED MATERIALS

- A. Salvage existing materials for re-installation as directed by Owner. Coordinate locations for storage of salvaged materials with Owner.

3.5 CLEANING AND REPAIR

- A. Existing Materials: Clean and repair existing materials and equipment which remain or are to be re-used.
- B. Existing Panel boards: Clean exposed surfaces and check tightness of all electrical connections. Replace damaged circuit breakers with units of compatible construction and provide closure plates for vacant positions.
- C. Existing Lighting Fixtures: Where existing lighting fixtures are indicated to remain, clean reflector and lens and replace lamps.
 - 1. Use mild detergent to clean all interior and exterior surfaces; rinse with clean water and wipe dry; allow to dry thoroughly prior to re-installation.
 - 2. Replace lamps and broken electrical components. Replace cracked or broken lenses and louvers with new identical materials.
 - 3. Ballasts: Replace ballasts in all fluorescent lighting fixtures to remain or to be re-used with new ballasts as specified.

END OF SECTION

SECTION 26 05 19

LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all other Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Provide systems of wires and cables for electric power, signaling and control.
- B. Related work specified in other sections:
 - 1. 26 00 00 - Electrical
 - 2. 26 05 20 - Cable Connections
 - 3. 26 05 23 - Control Voltage Electrical Power Cables
 - 4. 26 05 32 - Raceways
 - 5. 26 05 33 - Boxes for Electrical Systems

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 REFERENCED STANDARDS

- A. ICEA 5-61-402 Thermoplastic Insulated Wire and Cable
- B. ICEA 5-66-524 Cross Linked Thermosetting Polyethylene Insulated Wires and Cables
- C. ICEA 5-68-516 Ethylene Propylene Rubber Insulated Wire and Cable
- D. ICEA 5-19-81 Rubber Insulated Wire and Cable
- E. ANSI 1581 Standard of Electrical Wires, Cables, and Flexible Cords.
- F. UL 83 Thermoplastic Insulated Wires and Cables

- G. ASTM B3 Standard Specification for Soft or annealed Copper Wire
- H. ASTM B8 Standard Specification for Concentric Lay Standard Copper
 Conductors

1.5 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Provide closeout documents as required in Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver conductors and cable assemblies to the project in the manufacturer's standard reels or boxes marked with conductor material, insulation type, conductor size and U.L. Label.
- B. Store conductors and cable assemblies in a clean, dry location to prevent damage from moisture, dust, personnel and equipment.
- C. Handle conductors and cables in a manner to prevent damage to conductor, insulation, jackets, and identifying markings.

1.7 MANUFACTURERS

- A. The material shall be the product of a manufacturer with a minimum of ten years experience in the manufacture of similar material.
- B. Acceptable Manufacturers:
 - 1. Cerro Wire, Inc.
 - 2. Encore Wire
 - 3. General Cable
 - 4. Southwire Company

1.8 WARRANTY

- A. The material shall be warranted to be free from defect and in proper working order for one year following the date of final acceptance.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Copper Conductors

1. Conductors shall be copper unless specifically noted otherwise on the Drawings.
2. Copper conductors shall be soft drawn annealed copper, minimum conductivity 98% of pure copper per ASTM ASTM-B3.
3. Sizes No. 10 AWG and smaller shall be solid conductor, single strand.
4. Sizes No. 8 AWG and larger shall be concentric lay Class B stranding.
5. Shall conform to the Conductor Properties proscribed in the NEC.

B. Insulation

1. Type THW: 600 volt moisture and heat resistant thermoplastic rated 75 Deg.C. in wet or dry locations.
2. Type THW-2: 600 volt moisture and heat resistant thermoplastic rated 90 Deg.C. in wet or dry location.
3. Type THWN: 600 volt moisture and heat resistant thermoplastic rated 75 Deg.C. in wet or dry.
4. Type THWN-2: 600 volt moisture and heat resistant thermoplastic rated 90 Deg.C. in wet or dry locations.
5. Type XHHW: 600 volt moisture resistant cross linked polyethylene rated 75 Deg.C. in wet or dry locations.
6. Type XHHW-2: 600 volt moisture resistant cross linked polyethylene rated 90 Deg.C. in wet or dry locations.

PART 3 - EXECUTION

3.1 USES PERMITTED

- A. Unless specifically noted on the drawings, permitted by the NEC and local codes and ordinances, wiring shall be Type THHN/THWN-2 or XHHW-2 installed in metal raceways as specified in 26 05 32, Raceways.

3.2 COLOR CODING

- A. Where available, insulation shall be color coded by factory pigmentation for each phase and each voltage system employed on the project.
- B. 120/208 and 120/240 volt systems:
1. Phase A - Black
 2. Phase B - Red
 3. Phase C - Blue
 4. Neutral - White
 5. Ground - Green
- C. Where factory pigmentation is not available, code conductors with 1-1/2" colored tape band at each terminal and at each pull or junction box.

3.3 GROUNDING CONDUCTORS

- A. All branch circuits and feeders shall include an insulated equipment grounding conductor. Raceway systems shall not be used as the sole equipment grounding path without specific approval.

3.4 MULTIWIRE BRANCH CIRCUITS

- A. Multiwire branch circuits shall not be permitted unless required by the device served, such as for connection to modular furniture systems or track lighting systems.
- B. Where multiwire branch circuits are required, branch circuit breakers shall be two or three pole with common trip and one handle.

3.5 MINIMUM SIZE

- A. Conductors shall be of the minimum size shown on the drawings, lighting and power branch circuit wiring shall be minimum No.12 AWG.
- B. Feeder circuit wiring shall be sized to limit the effect of voltage drop, based on the actual installed conductor length to limit voltage drop to 2% of nominal system voltage.
- C. Branch circuit wiring shall be size to limit the effect of voltage drop, based on the actual installed conductor length, to limit voltage drop to 3% or less of nominal system voltage.
- D. Circuits shall be grouped in raceways and grouped together when passing through enclosures to have phases and neutral grouped together to minimize circuit reactance.

3.6 INSTALLATION

- A. Examine the system in which the conductors are to be installed for defects in equipment and installation which may cause damage to the conductors, insulation, or jackets.
- B. Pull a swab or mandrel through conduit systems immediately before pulling conductors to insure a full bore, clean raceway system.
- C. Do not exceed the conductor manufacturer's maximum pulling force or minimum bending radius.
- D. Use pulling lubricant compound where necessary and recommended by the manufacturer.
- E. Conductors or cables which have insulation or jackets damaged in the pulling process shall be removed and replace with new material.

3.7 FIELD QUALITY CONTROL

- A. Test all wiring insulation with a megohm meter prior to energization:
 - 1. Phase to ground
 - 2. Phase to phase
 - 3. Phase to neutral
 - 4. Neutral to ground
- B. Perform test in accordance with manufacturer's recommendation and to meet manufacturer's published minimum insulation values.
- C. Correct all defects revealed by such tests including replacing material with new as required.

END OF SECTION

SECTION 26 05 20
CABLE CONNECTIONS

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1- General Requirements and related documents.
- B. All sections of this Specification.

1.2 DESCRIPTION

- A. Work Included: Provide wire connections and devices to be readily identifiable, mechanically and electrically secure wiring system.
- B. Related work specified in other sections:
 - 1. 26 05 19 - Low Voltage Electrical Power Conductors and Cables

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Provide closeout documents as required in Division 1.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Connections shall be made in atmospheres that are free from dirt, moisture, and elements which may be damaging.

1.6 MANUFACTURERS

- A. The materials shall be the product of a manufacturer with a minimum ten years experience in the manufacture of similar materials.
- B. Acceptable manufacturers are listed with the products.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Spring Connectors: Ideal "Wingnut" 3M-Scotch, Buchanan, and Thomas and Betts.
- B. Terminal Connectors: O-Z/Gedney, Burndy, and Thomas and Betts.
- C. Splice Connectors: O-Z/Gedney or Burndy with insulating cover.
- D. "T" and Parallel Connectors: O-Z/Gedney or Burndy with insulating cover.
- E. Vinyl Plastic Tape: 3M-Scotch #33 or #88, Plymouth and Okonite.
- F. Rubber Tape: Okonite, 3M-Scotch and Plymouth.
- G. Colored Tape: 3M-Scotch, Plymouth.
- H. Wire Ties: Thomas and Betts "Ty-Rap", Ideal and Panduit.
- I. Tie Mounts, Plates, Anchors: Thomas and Betts, Ideal, and Panduit.
- J. Wire Tags: Self-laminating, cloth, wrap-on type by Thomas and Betts, Ideal, and Brady.
- K. Terminal Strips: Nylon; 600 volt; modular plug-on construction; tubular compression slip-in terminals properly sized; complete with mounting track, end clips, and anchors by Allen-Bradley, Square D, and Buchanan.
- L. Cable and Cord Fittings: Crouse-Hinds with wire mesh grip or Appleton.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine wires to be joined, tapped, spliced, terminated, and their connecting devices for defects which may affect the mechanical and electrical integrity of the connection.
- B. Do not proceed until defects are corrected.

3.2 PREPARATION

- A. Remove proper amount of insulation necessary for connection, clean conductors.

3.3 INSTALLATION

- A. No. 10 Wire and Smaller: Connect with spring connectors, terminate at terminal strips.
- B. No. 8 Wire and Larger: Connect and terminate with above specified tape half-lapped to produce a dielectric value equal to wire insulation.

- C. Train, hold, clamp, and tag wiring in cabinets, pull boxes, panels, and junction boxes with above specified devices.
- D. Splices in feeders and mains may only be made where designated on the drawings and where prior approval is obtained from the Architect.
- E. Install terminal strips in enclosures without means for termination of wiring.
- F. Install cable and cord grips on all cables and cords, entering enclosures. Use wire mesh grips where necessary for strain relief.

3.4 FIELD QUALITY CONTROL

- A. Test: Connections shall be resistance tested with megohm meter as specified for wire.

3.5 ADJUSTMENTS

- A. Assure that wire connections made by others in equipment furnished by others are mechanically and electrically sound prior to energization.

END OF SECTION

SECTION 26 05 23

CONTROL - VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all other Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Work Included: Provide power wiring, raceways, and connections for items of equipment and control systems.
- B. All wiring for every system shall be installed in metal conduit. Refer to Section 26 05 32 Raceways for conduit types and materials for specific locations and applications.
- C. Related work specified in other sections:
 - 1. 23 09 00 - Instrumentation and Controls for HVAC
 - 2. 26 00 00 - Electrical
 - 3. 26 05 19 - Low Voltage Electrical Power Conductors and Cables
 - 4. 26 05 32 - Raceways
 - 5. 26 28 16 - Enclosed Switches and Circuit Breakers

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 WARRANTY

- A. The material shall be warranted to be free from defect and in proper working order for one year following the date of final acceptance.

1.5 COORDINATION

- A. For equipment furnished under other Divisions, obtain equipment supply and wiring requirements from the Contractor supplying the equipment.

- B. For equipment furnished under Division 23, obtain complete temperature control system drawings, and power supply and interlock wiring requirements from the Contractor furnishing the systems.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Refer to related work specified in other sections for material requirements.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Work Included: The Electrical Contractor shall provide:
 - 1. Branch circuit and motor feeder circuit conductors, raceway, connections, and overcurrent protection for each motor or item of equipment furnished by the Owner or other Contractors.
 - 2. Motor Control Centers, where indicated on the drawings.
 - 3. Installation of motor controllers furnished by the Owner or other Contractors, along with branch circuit and motor feeder circuit conductors, raceway, and connections in accordance with the manufacturer's approved wiring diagrams.
 - 4. Disconnect switches and combination disconnect switches and motor controllers, where indicated on the drawings or required by codes, except as provided as an integral part of manufactured equipment.
 - 5. Power supply conductors, raceway, connections, and overcurrent protection for input power to HVAC Temperature Controls, HVAC Automation, and HVAC Energy Management Systems in accordance with approved rough-in and connection diagrams furnished by the system suppliers.
 - 6. The above represents an outline of the work for the purpose of describing one division of the work which is acceptable to ensure that all work is contained within the General Contract. Nothing herein shall be construed to confine the General Contractor from assigning the work to any member or group of contractors deemed best suited to executing the work to affect the contract. Refer to specific bidding instructions of the General Contractor for the actual division of the work. The General Contractor is fully responsible for the installation of complete, operating systems in accordance with the functional intent of the specifications.
- B. Work Not Included: The Mechanical Contractor shall provide:
 - 1. Motors and equipment, erected in place and ready for final connection of power supply wiring, along with manufacturer's approved wiring diagrams.
 - 2. Motor controllers, in suitable enclosures and of the type and size in accordance with the manufacturer's recommendations and NEMA requirements, along with properly sized overload elements and approved wiring diagrams.

3. Disconnecting switches or devices which are normally provided as a part of manufactured equipment.
 4. Rough-in and connection diagrams for input power supply and connections for the HVAC Temperature Control, HVAC Automation, and HVAC Energy Management Systems.
 5. Conductors, raceways, devices, and connections for low voltage control, line voltage control, and signaling systems for the HVAC Temperature Control, HVAC Automation, and HVAC Energy Management Systems in accordance with the provisions of Division 26, and approved systems shop drawings to provide complete operating systems in accordance with the functional requirements of the specifications.
 6. The above represents an outline of the work for the purpose of describing one division of the work which is acceptable to ensure that all work is contained within the General Contract. Nothing herein shall be construed to confine the General Contractor from assigning the work to any member or group of contractors deemed best suited to executing the work to affect the contract. Refer the specific bidding instructions of the General Contractor for the actual division of work. The General Contractor is fully responsible for the installation of complete, operating systems in accordance with the functional intent of the specifications.
- C. Completely connect all electrical consuming items of mechanical equipment, kitchen equipment, shop equipment, etc., provided by the Owner or other trades. Outlets of various types have been indicated at equipment locations, but no indications or exact location or scope of work is indicated on the accompanying drawings.
- D. Refer to details and information furnished by the Owner and various equipment suppliers for equipment wiring requirements and to the Plumbing and Heating, Ventilating and Air Conditioning Specifications for the scope of the connections to equipment provided under those sections, and determine from the various trades by actual measurements at the site, and by direction from the Owner and the Architect the exact locations of all items. Roughing-in drawings, wiring diagrams, etc., required for the proper installation of the electrical work will be furnished by applicable trades furnishing equipment. Request the drawings and information required in writing to the equipment supplier in ample time to permit preparation of the drawings and to permit proper installation of all wiring. Obtain from those furnishing equipment the size and type of service required for each motor or piece of electrical equipment and verify that the service to be installed is compatible.

3.2 INSTALLATION

- A. All conduits shall terminate in conduit boxes on motors where possible. When motors are direct connected, the conduit may continue rigid into the box, but when motors drive through belts and have sliding bases, a piece of flexible liquid tight conduit not less than 12 inches long shall be connected between the rigid conduit and the motor

terminal. Where motors are not provided with conduit boxes, terminate the conduit in a conduit at the motor.

- B. Where disconnecting switches are not provided integral with the control equipment for motors, provide and install a disconnect switch in the circuit to each motor where indicated and required by code. Switches shall be installed as close as possible to the motor or controls they serve and they shall be within sight of the motor or control circuit.
- C. Be responsible for installing all conductors and protective devices serving equipment motors furnished by others in strict conformance with all applicable codes, regardless of any discrepancy in plans and/or mechanical equipment sizes variations, unless covered by directives issued by the Architect.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all other Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Provide a grounding electrode for the facility and a ground electrode conductor system to connect to the electric service main equipment.
- B. Provide supplementary grounding electrodes as specified herein.
 - 1. Provide connections from the grounding electrode system to:
 - 2. The electric power system grounded circuit conductor (neutral).
 - 3. The electric power system non-current carrying enclosures and equipment ground conductors (equipment ground).
- C. Provide connections from the grounding electrode system to auxiliary ground conductors for data and voice communication systems (isolated ground).

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 REFERENCED STANDARDS

- A. National Electrical Code, NFPA 70.
- B. EIA/TIA Standard 607
- C. IEEE - Standard 142 - Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- D. IEEE Standard 81 - Guide for Measuring Earth Resistivity.

1.5 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Provide closeout documents as required in Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver conductors and cable assemblies to the project in the manufacturer's standard reels or boxes marked with conductor material, insulation type, conductor size and U.L. Label.
- B. Store conductors and cable assemblies in a clean, dry location to prevent damage from moisture, dust, personnel and equipment.
- C. Handle conductors and cables in a manner to prevent damage to conductor, insulation, jackets, and identifying markings.

1.7 MANUFACTURERS

- A. The materials shall be the products of a manufacturer with a minimum of ten years experience in the manufacture of similar material.
- B. Acceptable manufacturers shall be as listed with the material descriptions.

1.8 WARRANTY

- A. The material shall be warranted to be free from defect and in proper working order for a period of one year following the date of final acceptance.

PART 2 - PRODUCTS

2.1 GROUND RODS

- A. Standard ground rods shall be 3/4 inch diameter, 10 foot length, copper clad steel, equal to Thompson Company.

2.2 CONDUCTORS

- A. Conductors buried in contact with the earth shall be bare copper, solid for sizes up to No. 6 AWG, concentric lay strand for sizes No. 8 AWG and larger.
- B. Conductors for installation below raised access floor systems shall be bare copper, solid for sizes up to No. 6 AWG, concentric lay strand for sizes No. 8 AWG and larger.

- C. All other grounding conductors shall be copper conductor, Type THWN 600 volt 90 Deg.C. thermoplastic insulation, green color where available.

2.3 CONNECTIONS

- A. All connections made below grade, in inaccessible locations, and all connections and splices in the grounding electrode conductor system shall be made by exothermic weld process equal to Cadweld. Provide polyethylene inspection well covers and lids equal to Erico #T416B.
- B. All other connections shall be hydraulically crimped irreversible connectors equal to Thomas and Betts 54000 Series.
- C. Connections to raised access floor system pedestals shall be Thomas and Betts 38268 malleable iron mechanical clamp.
- D. Connections to cable trays shall be Thomas and Betts 10105 malleable iron mechanical clamp.
- E. Connections to domestic cold-water piping shall be Thomas and Betts GUV Series copper alloy U-bolt and mechanical clamp.
- F. Connections to building structural steel shall be exothermic weld equal to Cadweld.
- G. Connections which require flexibility for movement, expansion, or vibration shall be made with flexible flat conductor, multiple strands of 30 gauge copper conductors or equivalent circular mil area to the primary ground conductor. Protect ends with copper bolt hole end pieces.

2.4 CONDUITS

- A. Provide malleable iron conduit grounding bushings where:
 - 1. Metallic raceways terminate at metal housings without mechanical and electrical connection to housing.
 - 2. At each end of metallic conductors for grounding conductors where conduits are electrically non-continuous.
 - 3. At the ends of service entrance conduit.

PART 3 - EXECUTION

3.1 GROUNDED CIRCUIT CONDUCTOR

- A. Bond the grounding electrode system to the grounded circuit conductor (neutral conductor) at one location only, on the supply side of the service disconnecting means, with a neutral disconnecting link as required by the NEC.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Bond the non-current carrying parts of the electric power system to the grounding electrode conductor at the service disconnecting means. From this point forward, all non-current carrying parts of the electric power system shall be electrically connected and continuous by means of:
 - 1. Electrically continuous equipment enclosures, metallic boxes and metallic raceways connected with U.L. Listed connectors and couplings.
 - 2. Equipment grounding conductors supplementary to metallic raceway systems where shown on the Drawings.
 - 3. Equipment grounding conductors in non-metallic raceway systems and in flexible metal conduit systems.
 - 4. Where permitted under other sections of the Specification, the insulated grounding conductor provided in Type MC cable will be considered an acceptable equipment grounding conductor.
 - 5. Uninsulated grounding strips and spiral wrap provided in Type AC cable is not an acceptable grounding conductor.

3.3 TESTING

- A. Grounding Electrode:
 - 1. The earth resistance of the main ground electrode shall be not more than 5 ohms.
 - 2. Perform a measurement of ground resistance by one of the means described in IEEE Standard 81, Guide for Measuring Earth Resistivity.
 - 3. Provide written certification of the ground resistance measurements upon request.
- B. Grounding Continuity:
 - 1. Provide continuity tests and checks of equipment grounding and isolated grounding conductor systems to ensure electrical continuity.
 - 2. Provide written certification of continuity checks upon requests.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1- General Requirements and related documents.
- B. All sections of this Specification.

1.2 DESCRIPTION

- A. Work Included: Provide miscellaneous materials for the supporting of electrical material and equipment.
- B. Related work specified in other sections:
 - 1. 26 00 00 - Electrical
 - 2. 26 05 32 - Raceways
 - 3. 26 05 33 - Boxes for Electrical Systems
 - 4. 26 27 16 - Electrical Cabinets and Enclosures

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Provide closeout documents as required in Division 1.

1.5 MANUFACTURERS

- A. Listed with Materials.
- B. Acceptable Manufacturers
 - 1. Unistrut
 - 2. Caddy
 - 3. Thomas & Betts

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Continuous Slotted Channel: #12-gauge steel, electrogalvanized, with zinc chromate, bases and dimensions as required for application.
- B. Hanger Rods: Continuous thread, electrogalvanized, with zinc chromate, sizes as required for loads imposed.
- C. Hex Head Cap Screws and Nuts: No. H-113 and No. H-114, respectively.
- D. One-Hole Pipe Straps: Series HS-100, galvanized steel
- E. Single Bolt Channel Pipe Straps: Steel, with machine screws and nut, Series C-105 and Series C-106.
- F. Lay-In Pipe Hanger: Series C-149.
- G. Conduit and Pipe Hanger: Series 6H.
- H. Beam Clamps: Series 500, RC, EC, and PC for applications.
- I. Concrete Inserts, Spot: Series D-256 or No. D-255.
- J. Concrete Inserts, Channel: Series D-980 or Series D-986.
- K. Riser Clamps: Series C-210.
- L. Cable Supports: O-Z/Gedney Type S.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Carefully lay out and provide concrete inserts.
- B. Securely fasten and support conduits and raceways to the building structure.
- C. Suspend horizontal runs of conduit and raceways from the floor and roof construction by rod hangers spaced 10 feet on less on centers for sizes 2-1/2 inches and greater and 9 feet or less on centers for sizes 2 inch and smaller.
- D. Fasten single runs of conduit to the structure with one-hole pipe straps and beam clamps or hang on rod hangers.
- E. Support multiple runs of conduit and raceways from continuous channel inserts or from trapeze hangers constructed of rod hangers and channels.

- F. Fasten single conduits to rod hangers with adjustable lay-in pipe hangers or for 2 inches and smaller conduits with Series 6H pipe hangers.
- G. Fasten conduits to channels with pipe channel straps.
- H. Support conduits and raceways within 3 feet of each end of each bend, of each termination, and at other intervals to maintain horizontal and vertical alignment without sag and deformation.
- I. Do not use cable, strap, and wire hangers as fasteners.
- J. Provide riser clamps for conduits at floor lines. Provide wire and cable supports in pull boxes for risers in accordance with NEC Section 300-19 and Table 300-19 (a).
- K. Install supports to permit equally distributed expansion and contraction of conduits and raceways with expansion joints. Use guides or saddles and U-bolts and anchors designed for equal effectiveness for both longitudinal and transverse thrusts.
- L. Do not support conduits and raceways for equipment connections.
- M. Provide special supports with vibration dampers to minimize transmission of vibrations and noises.
- N. Provide trapeze hangers for conduits and raceways where routing interferes with ducts.
- O. Provide hangers, racks, cable cleats and supports for wires and cables in cable chambers and other locations to make a neat and substantial installation.
- P. Provide angle iron and channel supports to the floor and structure for panelboards, cabinets, pull and junction boxes. Support independently from entering conduits and raceways. Provide supports as specified for conduits and raceways for outlet boxes and pull boxes 100 cubic inches and smaller.
- Q. Provide supports sized for the ultimate loads to be imposed.

3.2 CLEANING

- A. Clean surfaces to be painted.

END OF SECTION

SECTION 26 05 32

RACEWAYS

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all other Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Work Included: Provide a mechanically and electrically complete conduit system.
- B. Related work specified in other sections:
 - 1. 26 00 00 - Electrical
 - 2. 26 05 19 - Low Voltage Electrical Power Conductors and Cables
 - 3. 26 05 29 - Hangers and Supports for Electrical Systems
 - 4. 26 05 23 - Control Voltage Electrical Power Cables

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Certificates:
 - 1. Labels of Underwriters' Laboratories, Inc. affixed to each item of material.
 - 2. If materials are by manufacturers other than those specified submit certification that material meets applicable Underwriters' Laboratories, Inc. Standards.
- D. Provide closeout documents as required in Division 1.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Protect conduits and finishes from damage.

1.6 MANUFACTURER

- A. The materials shall be the products of a manufacturer with a minimum of ten years experience in the manufacture of similar equipment.
- B. Acceptable Manufacturers
 - 1. Metallic Conduits: Allied, and Wheatland.
 - 2. Nonmetallic Conduits: Cantex, and SEDCO.

1.7 WARRANTY

- A. The materials shall be warranted to be in proper working condition for a period of one year following the date of final acceptance.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Rigid Metal Electrical Conduit: Hot-dipped galvanized steel with zinc coated threads and an outer coating of zinc bichromate, complete with one coupling and one end thread protector. Intermediate metal conduit (IMC) is not allowed.
- B. Electrical Metallic Tubing: Welded, electro-galvanized thin wall steel tubing.
 - 1. Conduit for power wiring shall be natural electro galvanized.
 - 2. Conduit for other systems shall be color coded in accordance with Section 26 05 23 - Control Voltage Electrical Power Cables.
- C. Flexible Metal Electrical Conduit: Hot-dipped galvanized steel strip core with integral copper ground wire on sizes 1-1/4" and smaller.
- D. Liquidtight Flexible Metal Electrical Conduit: Hot-dipped galvanized steel strip core with extruded polyvinyl jacket.
- E. Rigid Nonmetallic Electrical Conduit: Schedule 40 heavy wall polyvinylchloride, high impact resistant.
- F. Elbows and Bends:
 - 1. All Types: Size 1-1/4 inch and larger shall be factory manufactured.
- G. Bushings:
 - 1. 1-1/4" and Smaller: Same material as the conduit with which they are installed.
 - 2. 1-1/2" and Larger: Hot-dipped galvanized with thermosetting phenolic insulation, 150 Deg.C.
- H. Locknuts:

1. 1-1/2" and Smaller: Zinc plated heavy stuck steel, O-Z/Gedney.
 2. 2" and Larger: Cadmium plated malleable iron, O-Z/Gedney.
- I. Hubs: Cadmium plated malleable iron, tapered threads, neoprene "O" ring, insulated throat, O-Z/Gedney.
 - J. E.M.T. Compression Connectors: Gland compression type, zinc plated steel body, cadmium plated, malleable iron nut, insulated throat, O-Z/Gedney.
 - K. E.M.T. Compression Couplings: Gland compression type, zinc plated steel body, cadmium plated malleable iron nut, O-Z/Gedney.
 - L. Liquidtight Conduit Connectors: Cadmium plated malleable iron body and nut, cadmium plated steel ferrule, insulated throat, integrally cast external ground lug, O-Z/Gedney.
 - M. Seals for Watertight Wall and Floor Penetrations: Malleable iron body, oversize sleeve, sealing ring, pressure clamp and rings and sealing grommet, hex head cap screws, O-Z/Gedney.
 - N. Seals for Penetrations through Existing Walls: Thunderline Corporation Link-Seal watertight sleeves, complete with wall and casing seals.
 - O. Fire Seals: Galvanized iron pipe sleeves sealed with approved foam type fireproofing.
 - P. Expansion Fittings: Hot-dipped galvanized malleable iron with bonding jumpers selected for linear or linear with deflection, as required.
 - Q. Accessories: Reducers, bushings, washers, etc., shall be cadmium plated malleable iron on the forms and dimensions best suited for the application.
 - R. Identifying Tape for Underground Conduits: Polyethylene tape, 6 inches wide, with continuous printing along length, Brady Identoline:
 1. For Electric Power Conduits: Yellow with black letters.
 2. For Other Services: Green with black letters.
 - S. Sleeves: 22 gauge galvanized steel sleeves where conduits pass through walls and floors. Standard galvanized steel pipe where conduits pass through beams, outside walls, or structural members.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine surfaces to which conduits are to be secured for:
 1. Defects which will adversely affect the execution and quality of work.
 2. Deviations from allowable tolerances for the building material.

- B. Do not start work until defects and deviations are corrected.

3.2 INSTALLATION

- A. Size conduits as indicated on the drawings and as required by the NEC for the number and sizes of wires to be drawn into conduit. Do not use conduit sized less than 3/4" unless specified otherwise.
- B. Conceal conduits from view in all areas except mechanical and electrical equipment rooms and crawl spaces. Should it appear necessary to expose any conduit:
 - 1. Bring to the attention of the Architect, immediately, and
 - 2. Rearrange the work to facilitate an approved installation.
- C. Install all conduits at elevations and locations to avoid interference with grading of other work, the structure, finished ceilings, walls. Avoid causing cutting of masonry units.
- D. To prevent displacement, securely support and hold in place all conduits installed in advance of other work and to be concealed in the building structure.
- E. Carefully lay out conduits run within the structure, such as floors, beams, walls, to avoid densities excessive for the construction. Relocate those conduits when excessive densities occur.
- F. Ream, remove burrs, and swab inside conduits before conductors are pulled in.
- G. Cap or plug conduits with standard manufactured accessories as soon as the conduits have been permanently installed in place.
- H. Bends and offsets in 1" and smaller conduits may be done with approved bending devices. Do not install conduits which have had their walls crushed and deformed and their surface finish damaged due to bending.
- I. Where space conditions prohibit the use of standard ells, elbows, and conduits, use cast ferrous alloy fittings of such forms and dimensions as best required for the application.
- J. Make all conduit joints mechanically tight, electrically continuous, and watertight. Pitch conduits in a manner to avoid creating moisture traps.
- K. Install insulated throat threaded hubs on conduits entering enclosures without threaded hubs where exposed to damp or wet locations.
- L. Connect and couple E.M.T. with compression type fittings. Do not use indentor and set screw fittings.
- M. Install and neatly rack exposed conduits parallel with and perpendicular to the building walls. Do not install exposed diagonal conduit runs.

- N. Route and suspend conduits crossing expansion joints to permit expansion, contraction, and deflection utilizing approved fittings to prevent damage to the building, conduits, and supporting devices in accordance with the National Electrical Code.
- O. Do not run conduits exposed on the roof unless approval is obtained prior to installation.
- P. Do not place conduits in close proximity to equipment, systems, and service lines, such as hot water supply and return lines, which could be detrimental to the conduit and its contents. Maintain a minimum 3" separation, except in crossing, which shall be a minimum 1".
- Q. Conduit sleeves shall be sized to permit insertion of conduit with adequate clearance for movement due to expansion and contraction. Where conduits pass through outside walls, watertight fittings, as specified herein, shall be used.
- R. All stub-ups of PVC conduit runs shall be made with rigid galvanized steel conduit with protective wrapping. Provide corrosion resistant protective wrapping from where the galvanized conduit begins to 4" above the finished floor.

3.3 USES PERMITTED

- A. Rigid Metal Conduit:
 - 1. Exterior conditions above grade.
- B. Schedule 40 PVC:
 - 1. Below grade exterior to the building.
- C. Electrical Metallic Tubing:
 - 1. All uses above grade interior to the building, except as limited elsewhere in this section.
- D. Flexible Metal Conduit:
 - 1. Final connection to vibrating or adjustable equipment.
 - 2. Connection to vibrating equipment shall contain one 90 degree bend.
- E. Liquid tight Flexible Metal Conduit:
 - 1. All uses permitted for flexible metal conduit.
 - a. Exterior to the building.

END OF SECTION

SECTION 26 05 33

BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all of the Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Work Included: Provide outlet boxes for the installation of wiring devices, lighting fixtures, and power and control connections.
- B. Related work specified in other section:
 - 1. 26 00 00 - Electrical
 - 2. 26 27 26 - Wiring Devices
 - 3. 26 05 23 - Control-Voltage Electrical Power Cables

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 SUBMITTALS

- A. Samples: Provide samples upon specific request.
- B. Submit product data under provisions of section 26 00 00 Electrical.
- C. Provide closeout documents as required in Division 1.

1.5 MANUFACTURERS

- A. Listed with Materials.
 - 1. Appleton Electric Company
 - 2. Raco
 - 3. Steel City
 - 4. Crouse Hinds

5. Hubbell
6. Raceway Components
7. Walker

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Flush Mounted Outlet Boxes: Standard, stamped galvanized steel with factory conduit knockouts, one piece and welded construction:
 1. Series 4S and 4S0 square boxes with covers.
 2. Series M1, M2, M3 - 250 and Series M1, M2, M3 - 350 masonry boxes with covers.
 3. Series 2G and GC-5075 switch boxes with covers.
 4. Series OCR concrete rings with Series OCP and OCP-3/8 back plates.
 5. Series 40 and 40D octagonal boxes with raised covers.
 6. Series SX expandable bar hangers.
- B. Surface Mounted Outlet Boxes: Cast metal with threaded hubs. Type FS and FD with covers of form suited to the application.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine building structure to which outlet boxes are to be secured for defects which affect the execution and quality of work.
- B. Do not start work until defects are corrected.

3.2 PREPARATION

- A. Carefully measure and lay out exact locations in conference with the Construction Manager.
- B. Owner may change outlet box locations a distance of 5 feet before rough-in without additional cost.

3.3 INSTALLATION

- A. Provide the appropriate cover plate for all boxes in all applications. No unused boxes shall be provided without a cover plate.
- B. In dry walls for single and two gang outlets provide 4S and 4D boxes; for 3 or more outlets use masonry boxes.

- C. In exposed work, exterior of the building, in wet locations, and flush in non-waterproofed walls below grade provide FS and FD boxes.
- D. Submit for approval special boxes for special devices and applications. Size according to device and application in accordance with NEC.
- E. Install outlet boxes finished to within 1/8 inch of finished surfaces.
- F. Install center of box at heights above finished floor:
 - 1. Wall Switches: 45 Inches
 - 2. Convenience Outlets: 18 Inches
 - 3. Telephone/Data Outlets: 18 Inches
 - 4. Boxes Indicated Above Counters: 4 Inches above backsplash and trim, unless otherwise indicated.
- G. Provide standard manufactured plugs in unused openings of boxes.
- H. Provide boxes at the terminal of conduit runs to outlets and devices.
- I. Provide plaster rings and covers where required by the building structure.
- J. Label all junction boxes with circuit information or as to its use for special system equipment. Labels shall be typewritten, adhesive backed printed labels. Lettering shall be minimum 18-point type in basic black font.

3.4 CLEANING

- A. Clean surfaces to be painted.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCE DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all of the Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Provide identification of electrical equipment.
- B. Provide identification of over current devices.
- C. Provide identification of branch circuits, outlets, and wiring devices.
- D. Provide identification of required clear working spaces for electrical equipment.
- E. Provide identification of rooms and spaces for access by qualified personnel.
- F. Related work specified in other section:
 - 1. 26 05 33 - Boxes for Electrical Systems.
 - 2. 26 24 16 - Panelboards.

1.3 QUALITY ASSURANCE

- A. Signs and placards shall meet the requirements by OSHA.

1.4 SUBMITTALS

- A. Submit literature describing all labels, signage and marking materials to the Architect for approval prior to installation.
- B. Samples: Provide samples upon specific request.
- C. Submit product data under provisions of section 26 00 00 Electrical.
- D. Provide closeout documents as required in Division 1.

PART 2 - PRODUCTS

2.1 PLACARDS

- A. Placards shall be engraved phenolic name plates with engraved lettering engraved. Lettering shall be minimum 24-point type in basic block font.
- B. Placards shall be securely and permanently adhered to the equipment enclosures without fasteners or penetrations into the enclosures.
- C. Placards shall be color coded white placard with black lettering.

2.2 LABELS

- A. Labels shall be typewritten, adhesive backed printed labels. Lettering shall be minimum 18-point type in basic black font.

2.3 MARKING MATERIALS

- A. Materials for marking of required working clearance shall be adhesive backed yellow tape, equal to 3M Company 471 Series. Clean and prepare floor surface in accordance with manufacturer's instructions.

PART 3 - EXECUTION

3.1 SERVICE ENTRANCE EQUIPMENT

- A. Provide a placard for each service entrance equipment identifying:
 - 1. The name of the equipment.
 - 2. The utility company available fault current.
 - 3. The supply system voltage.
- B. Provide Feeder Protective Devices with a placard identifying the name of the device or circuit number and the name of the equipment or load served.

3.2 LIGHTING AND APPLIANCE PANELBOARDS

- A. Provide each panelboard with a placard identifying:
 - 1. The name of the equipment.
 - 2. The supply system voltage.
 - 3. The name of the equipment supplying the switchboard or panelboard.
 - 4. The circuit number of the overcurrent device supplying the panelboard.
- B. Provide each panelboard with a typewritten circuit directing card describing the name of the load served and the room number (3) where the devices are located. Reference

the room number(s) actually installed at the project, not the room numbers for Architectural construction documents.

3.3 OTHER EQUIPMENT INCLUDING DISCONNECT SWITCHES

- A. Provide other electrical and mechanical equipment with placards identifying.
 - 1. The name of the equipment.
 - 2. The name of the supply source equipment.
 - 3. The circuit number of the overcurrent device supplying the equipment.

3.4 OUTLET BOXES, JUNCTION BOXES AND WIRING DEVICES

- A. Provide labels affixed to the outside cover for each outlet box, junction box, and wiring device identifying the panel name and branch circuit numbers for the overcurrent devices supply the circuits.

END OF SECTION

SECTION 26 27 16

ELECTRICAL CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 REFERENCE DOCUMENTS

- A. Conditions of the Contract and Division 01 - General Requirements are hereby made a part of this section.
- B. All sections of this specification.

1.2 DESCRIPTION

- A. Work Included: Provide cabinets for the installation of wiring and equipment.
- B. Related work specified in other section:
 - 1. 26 00 00 - Electrical
 - 2. 26 24 16 - Panelboards
 - 3. 26 28 16 - Enclosed Switches and Circuit Breakers
 - 4. 26 05 23 - Control Voltage Electrical Power Cables

1.3 QUALITY ASSURANCE

- A. Source Quality Control: Tests to meet applicable Underwriters' Laboratories, Inc. Standards.
- B. Reference Standards:
 - 1. Underwriters' Laboratories, Inc. applicable Standards.
 - 2. National Electrical Code.
- C. Design Criteria: National Electrical Manufacturer's Association construction types based on environment.
 - 1. Indoor: NEMA Type 1
 - 2. Outdoor: NEMA Type 3R

1.4 SUBMITTALS

- A. Submit product data under provisions of section 26 00 00 Electrical.
- B. Shop Drawings shall include dimensions, knockout sizes and locations, material types and gauges, finishes, and installation methods.

- C. Certificates shall include labels of Underwriters' Laboratories, Inc., and National Electrical Manufacturer's Association affixed to each item.
- D. Provide closeout documents as required in Division 1.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. ABB/GE.
- B. Eaton.
- C. Square D Company.

2.2 MATERIALS

- A. For Panelboards:
 - 1. Same manufacturer as panelboard, boxes of code gauge steel, welded with edges turned to receive trim, and galvanized.
 - 2. Trim and doors No. 12 gauge steel minimum, hinged door, flush tumbler lock and catch keyed alike throughout the work, factory enamel finish, suitable for field color coat.
 - a. Flush: Overlap minimum 3/4 inches top, bottom, and sides.
 - b. Surface: Same size as cabinet.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine structure to which cabinets are to be secured for defects which affect the execution and quality of work.
- B. Do not start work until defects are corrected.

3.2 PREPARATION

- A. Carefully measure and lay out exact locations.
- B. Provide supports.

3.3 INSTALLATION

- A. Provide cabinets where indicated and where necessary.

- B. Provide flush type in finished areas centered in paneling and other Architectural features.
- C. Provide surface type in equipment rooms, above accessible finished ceilings, and in crawl spaces.
- D. Install lighting and power cabinets with tops 6 feet 6 inches above finished floor.
- E. Install cabinet trim and doors straight and plumb.

3.4 CABINET IDENTIFICATION

- A. Cabinets for all panelboards, switchboards, disconnect switches, transformers, motor starters, and electrical equipment furnished shall be provided with engraved phenolic lamacoid plastic name plates with 1/2-inch block engraving.
- B. Name plates shall give equipment designation as scheduled on the drawings, circuit number designation, and voltage and phase of service.

3.5 ADJUSTMENT AND CLEANING

- A. Adjust trims and doors for vertical and horizontal alignment.
- B. Clean surfaces to be painted.

END OF SECTION

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 REFERENCED DOCUMENTS

- A. Comply with Division 1 - General Requirements and related documents.
- B. Comply with all other Division 26 sections as applicable.
- C. Refer to other Divisions for coordination of work with other portions of work.

1.2 DESCRIPTION

- A. Work Included: Provide disconnect switches and enclosed circuit breakers for branch circuit, motor circuits, and items of equipment.
- B. Related work specified in other sections:
 - 1. Division 23
 - 2. 26 00 00 - Electrical

1.3 QUALITY ASSURANCE

- A. The equipment supplied and installed shall meet the requirements of the National Electrical Code and all applicable local codes and ordinances.
- B. All equipment supplied shall be Underwriter's Laboratories Inc. listed and so labeled.

1.4 REFERENCED STANDARDS

- A. UL 50 Cabinets and Boxes
- B. UL 98 Enclosed and Deadfront Switches
- C. UL 489 Molded Case Circuit Breakers
- D. UL 977 Fused Power Circuit Devices
- E. NEMA AB1 Molded Case Circuit Breakers and Molded Case Switches
- F. NEMA KS1 Enclosed Switches

1.5 SUBMITTALS

- A. Submit product data under provisions of section 26 00 00 Electrical.

- B. Submit shop drawings including:
 - 1. Enclosure outline drawings and dimensions.
 - 2. Nameplate schedule.
 - 3. Assembly ratings including:
 - a. Main lug ratings and location.
 - b. Voltage ratings.
 - c. Short circuit ratings.
 - 4. Conduit entry and exit locations, dimensions, and knock-outs.
 - 5. Cable terminal sizes.
 - 6. Fuse types and ratings.
 - 7. Manufacturer's literature describing circuit breakers and trip units.
- C. Provide closeout documents as required in Division 1.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and off loaded in accordance with the manufacturer's published instructions.
- B. Upon arrival, inspect equipment for damage insured in shipping.
- C. Store and protect equipment from moisture and dust by storing in a clean, dry, heated space. Provide additional heavy plastic cover to protect the equipment and components. Provide auxiliary heating in the sections in accordance with the manufacturer's recommendations.

1.7 MANUFACTURER

- A. The equipment shall be the product of a manufacturer with a minimum of ten years experience with the manufacture of similar equipment.
- B. Acceptable Manufacturers:
 - 1. ABB/GE.
 - 2. Eaton.
 - 3. Square D Company.

1.8 WARRANTY

- A. The equipment shall be warranted to be in proper working order for a period of one year following the date of final acceptance.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Enclosed Switches

1. Provide enclosed switches where indicated on the drawings or required by NEC.
2. Switches shall be NEMA Type HD, heavy duty, rated 600 volts, with quick-make, quick break switch units and external operator, rated 100,000 A.I.C.
3. Switches shall be fused or unfused as shown on the drawings and as required by NEC, capacity and number of poles as indicate don the drawings.
4. Enclosures shall be provided with interlocks to prevent opening the enclosure without first opening the switch and to prevent operating the switch with the enclosure open.
5. Enclosures shall be provided with a means for pad locking in the open position.
6. Enclosures shall be provided with an equipment grounding lug.
7. Enclosures for use on four wire shall be provided with an insulated neutral bus.
8. Line side and load side terminals shall be provided with insulating cover to prevent accidental contact.
9. Indoor locations shall be provided with NEMA Type 1 Enclosures.
10. Outdoor locations shall be provided with NEMA Type 3R Enclosures and watertight threaded hubs for conduit entry.

B. Enclosed Circuit Breakers

1. Provide enclosed circuit breakers or molded case switches where indicated on the drawings or required by the NEC.
2. Circuit breaker for rating 250 amperes or less shall be thermal magnetic molded case circuit breakers.
3. Circuit breakers 300 amperes through 1200 amperes shall be molded case, 100% rated, electronic trip, microprocessor based, true RMS sensing, with adjustable, defeatable instantaneous pickup.
4. Units shall be 600 volt or 250 volt as required and unless noted otherwise shall be 42,000 A.I.C.
5. Enclosures shall be provided with a means for pad locking in the open position.
6. Enclosures shall be provided with and equipment ground bus.
7. Enclosures for use on four wire systems shall be provided with an insulated neutral bus.
8. Line side and load side terminals shall be provided with insulating covers to prevent accidental contact.
9. Indoor locations shall be NEMA Type 1 Enclosures.
10. Outdoor locations shall be NEMA Type 3R enclosures and watertight hubs for threaded conduit entry.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Inspect building structure to which disconnects are to be secured for defects which affect the execution and quality of work.
- B. Do not start work until defects are corrected.

3.2 PREPARATION

- A. Carefully measure and lay out exact locations maintaining working clearances required by the National Electrical Code.

3.3 INSTALLATION

- A. Provide disconnects where indicated and where required by the National Electrical Code and all equipment where integral disconnects are not provided by the manufacturers.
- B. Provide disconnects mounted to building structure ahead of flexible conduit final connection to each fan powered terminal box.
- C. Install within sight of equipment served.
- D. Provide final connection to equipment served.
- E. Provide engraved lamicoid name plate secured to cabinet with designation of equipment served, operating voltage, and circuit designation.

END OF SECTION