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CENTRAL WASHINGTON UNIVERSITY PUBLIC WORKS PROJECT

CWU Samuelson Data Center AHU Replacement

CWU Contract No. 17456-02

Project Manual - Bid Documents

July 14, 2025

Prepared by:

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PROJECT DESCRIPTION:

Replace the existing Air Handling Units. This work will be done in 2 phases. The first phase of work includes a new chilled water Air Handler Unit (AHU-1) with an alternate to add ductless split systems to the UPS room. The second phase of work is to be bid at a later date. Phase 2 scope includes replacing the second air handler with a DX cooled Air Handler Unit and Condensing unit (AHU-2 & CU-1).

PUBLIC WORKS ROSTER PROCEDURE:

This campus project is being delivered using CWU's Public Works Roster process. Contractors interested in bidding must be listed on CWU's Public Works Roster and have a current Washington State Contractor's License.

ELECTRONIC BID OPENING:

The electronic bid opening process shall consist of an email submitted to Joe Chanes, Construction Project Coordinator, Joe.chanes@cwu.edu. The email submission shall have the **Bid Form** (See **Section 00 2000**) attached in PDF format. The email with the Bid Form must be submitted prior to **2:00 PM Pacific Time, Tuesday, September 09, 2025**. Upon receipt of the electronic bid, the CWU Construction Project Coordinator will reply to the email address and acknowledge receipt of the Bid Form.

BASE BID:

The base bid amount the Contractor submits shall be to furnish all labor, supervision, materials, services, and equipment required to replace the Air Handling Units in accordance with the Bid/Construction Documents. The Air Handling Unit is Owner Furnished and Contractor Installed.

PROJECT SCHEDULE:

July 22, 2025: Small Works Roster Contractors will be solicited by CWU to submit bids.
September 9, 2025: Bids must be received prior to **2:00 PM PST, Tuesday, September 9, 2025**.
October 1, 2025: Work may begin.
January 1, 2026: Project shall be completed by **Thursday, January 1, 2026**.

CWU CONTACT:

Direct all questions regarding the project to Joe Chanes, CWU Construction Project Manager, at Joe.chanes@cwu.edu (509)856-7107.
Copy questions regarding the project to David Johnson, MW Consulting Engineers, at Davidj@mwengineers.com (509)838-9020.

SITE VISIT:

A pre-bid site visit is highly recommended. Schedule the visit with Joe Chanes.

BID/CONSTRUCTION DOCUMENT CLARIFICATIONS AND PRODUCT SUBSTITUTIONS:

Any clarifications or product substitution requests to the Bid/Construction Documents must be submitted to the CWU Construction Coordinator and MW Consulting Engineers at least five (5) working days prior to the bid opening. Approval of proposed equals or substitutions will be made by addendum prior to receipt of bids and by a properly executed change order after receipt of bids.

AMENDMENTS TO BID SPECIFICATIONS:

Any amendment(s) to or error(s) in bid documents (specifications, drawings, etc.) called to the attention of the Owner will be corrected and furnished to all Contractors holding bid documents.

CONTRACTOR QUALIFICATIONS:

All bidders must be listed on the CWU Public Works Roster and have a current Washington State Contractor's License. Bidders must have successfully performed work of a similar scope and nature. Qualifications of bidders will be evaluated when determining award of bid.

PREVAILING WAGE:

The Contractor shall pay prevailing wages in accordance with RCW 39.12. Before payment is made by the Owner to the Contractor for any work performed by the Contractor and subcontractors whose work is included in the application for payment, the Contractor shall submit a statement of Intent to pay prevailing wages approved by the Department of Labor and Industries, certifying the rate of hourly wage paid.

APPRENTICE UTILIZATION PLAN: JULY 2025 NEW SECTION****

In accordance with July 1st 2025 revisions to RCW 39.04.350 based on House Bill 1549 the winning bidder shall submit an apprentice utilization plan to the awarding agency before receiving the notice to proceed. Contractor is responsible for submitting project to LNI through the contractor portal (<https://lni.wa.gov/licensing-permits/docs/ContractorPortalInstructions.pdf>). Contractor shall utilize apprentice templated supplied by Labor and Industries (L&I) and provided completed apprentice utilization to L&I at completion of the project to obtain the Notice of Completion (NOC).

RESERVED RIGHTS:

The Owner expressly reserves the rights: to accept or waive any and/or all irregularities in the bids submitted, to reject any and/or all bids, to base awards with due regard to quality, and to award to any bidder whose bid in the opinion of the Owner, is the lowest and best bid.

MINORITY AND WOMEN'S BUSINESS PARTICIPATION:

Minority and Women owned business are encouraged to submit bids. For assistance verifying certification, contact: Office of Minority and Women's Business Enterprises, 406 South Water, Mail Stop FK-11, Olympia WA 98504-4611, telephone (360) 753-9693.

DIVERSE BUSINESS INCLUSION:

The Owner is committed to providing the maximum practicable opportunity for participation by diverse businesses enterprises (DBE). DBE are defined as; small business, microbusiness, mini-business, minority owned business (MBE), and women owned business (WBE), as defined in RCW 39.26.010 and veteran-owned businesses as defined in RCW 43.60A.010. CWU strongly encourages contractors to work with DBE to meet or exceed the Owner's goals for each project of MBE 10%, WBE 6%, WA Small Business 5% and WA Veterans 5% participation. The successful bidder shall provide a plan to Michael Cox, CWU Construction Coordinator, for inclusion efforts undertaken to utilize DBE for any CWU goods and services contracted prior to commencing with the work.

**CENTRAL WASHINGTON UNIVERSITY
SAMUELSON DATA CENTER AHU REPLACEMENT
PUBLIC WORKS PROJECT
BID FORM**

TOTAL BASIC BID (Not including Washington State Sales Tax):

The undersigned hereby proposes to furnish all labor, supervision, materials, services, and equipment required for the SURC Carpet Replacement on the campus of Central Washington University in Ellensburg, Washington, and to perform the Work for the General Contract in accordance with the project Bid/Construction Documents for the following lump sum of money:

A) TOTAL BASIC BID (NOT INCLUDING WASHINGTON STATE SALES TAX):

_____ Dollars (\$ _____)
(Print written dollar amount in space above) (Print numeric amount in space above)

B.) ALTERNATE BIDS (NOT INCLUDING WASHINGTON STATE SALES TAX):

- 1. Provide ductless split systems for the UPS room.**

_____ \$ _____
(Please print written dollar amount in space above) (Print numeric amount in space above)

TIME FOR COMPLETION:

The undersigned hereby agrees to substantially complete all the work within 90 days after Notice to Proceed.

LIQUIDATED DAMAGES

The undersigned acknowledges and agrees to abide by all provisions of the "Liquidated Damages" section 3.07 of the General Conditions as it pertains to the Contractor for all work under this contract. The undersigned further agrees to pay the Owner as liquidated damages the sum of **\$500.00** for each consecutive calendar date that they fail to substantially complete work in the time specified in the contract documents.

ADDENDUM RECEIPT

Bidder acknowledges receipt, understanding and full consideration of the following addenda to the Contract Documents:

Addendum No. _____ Date _____

Addendum No. _____ Date _____

BID SECURITY:

Per RCW 39.08.010, no Bid Bond is required for projects under \$150,000. For projects over \$150,000, enclose a Bid Bond, certified check or cashier's check in the amount shown below, which shall be at least 5 % of the total bid.

LABOR AND INDUSTRIES FEES

In compliance with WAC 296-127 Contractor(s) shall pay to the Department of Labor and Industries required fee with each Statement of Intent to Pay Prevailing Wages or Affidavit of Wages Paid submitted to that department for certification and these costs shall be included in their bid.

Contractor Name _____

BID GUARANTEE

If written notice of acceptance of this bid is mailed, telegraphed or delivered to the undersigned within the time limit noted in the Instructions to Bidders sixty (60) calendar days after the date of bid opening, or any time thereafter before this bid is withdrawn, the undersigned will, within ten (10) days after the date of such mailing, telegraphing or delivering of such notice, execute and deliver a contract on the included Contract Forms to the Owner, together with satisfactory payment and performance bond in an amount equal to one hundred percent (100%) of the contract sum - base bid plus Owner accepted alternates (not including Washington State Sales Tax).

Name of Contractor: _____

Signed by: _____ Title: _____

Address: _____

Telephone: _____ Date: _____

Email address: _____

State of Washington Contractor's License No. _____

Federal Tax Identification No. _____

UBI Tax Number: _____

License Expiration Date: _____

The Firm represented by the above signature is:

Sole Proprietorship: _____

Partnership: _____

Corporation: _____

Other: _____

State of Incorporation: _____

END OF BID FORM

SCOPE OF WORK: The Contractor shall provide all labor, materials, and equipment necessary for the CWU Samuelson Air Handler replacement project in accordance with the Bid Documents.

PROJECT SITE: To find the exact location of the project, refer to cwu.edu/map for an interactive online campus plan. The Contractor shall schedule and coordinate all of the work with Joe Chanes, Construction Project Coordinator, joe.changes@cwu.edu, (509)856-7107. The Contractor shall communicate with Joe Chanes for any CWU shop support assistance as needed.

DESIGN AND CONSTRUCTION STANDARDS (DACS): CWU has developed a resources of typical design and construction standards associated with campus projects. These standards follow industry CSI Master format specifications and should be referenced for general guidelines on expectations of various building components and systems. For questions regarding the DACS and any conflict or request for material substitution, please submit them to the CWU project point of contact prior to the bid opening. The DACS are available for review here:

<https://www.cwu.edu/about/offices/facilities/capital-planning-projects/design-construction-standards.php#accordion-08813969-ac05-471c-bb1e-ad991be5b916-0>

GENERAL CONDITIONS: The Contractor shall comply with Section 00 7200 General Conditions for Washington State Facility Construction, which can be located at the following hyperlink:

<https://www.cwu.edu/about/offices/facilities/documents/cwu-general-conditions.pdf>

GENERAL CONDITIONS:

Regarding the project terms and conditions (Insurance, Prevailing Wages, Payment and Performance Bonds, Contract Sum, etc.), the Contractor shall comply with:

Section 00 7200 General Conditions for Washington State Facility Construction – access the following hyperlink:

<https://www.cwu.edu/about/offices/facilities/documents/cwu-general-conditions.pdf>

END OF SECTION

SUPPLEMENTAL CONDITIONS FOR WASHINGTON STATE FACILITIES CONSTRUCTION

(Paragraphs keyed to the State's General Conditions)

2.02 Replaces Section 2.02 – INSURANCE COVERAGE LIMITS and CERTIFICATES

A. Insurance Coverage Certificates and Policies

The Contractor shall furnish acceptable proof of insurance coverage on the state of Washington Certificate of Insurance form SF500A, dated 07/02/92 or ACORD form, as well as copies of insurance policies.

B. Required Insurance Coverages

1. For a contract less than \$100,000.00, the coverage required is:

- a. Comprehensive General Liability Insurance – The Contractor shall at all times during the term of this contract, at its cost and expense, carry and maintain general public liability insurance, including contractual liability, against claims for bodily injury, personal injury, death or property damage occurring or arising out of services provided under this contract. This insurance shall cover claims caused by any act, omission, or negligence of the Contractor or its officers, agents, representatives, assigns or servants. The limits of liability insurance, which may be increased as deemed necessary by the contracting parties, shall be:

Each Occurrence	\$1,000,000.00
General Aggregate Limits (other than products – commercial operations)	\$1,000,000.
Products – Commercial Operations Limit	\$1,000,000.00
Personal and Advertising Injury Limit	\$1,000,000.00
Fire Damage Limit (any one fire)	\$50,000.00
Medical Expense Limit (any one person)	\$5,000.00

- b. If the contract is for underground utility work, then the Contractor shall provide proof of insurance for that above in the form of Explosion, Collapse and Underground (XCU) coverage.
- c. Employers Liability on an occurrence basis in an amount not less than \$1,000,000.00 per occurrence.

2. For contracts over \$100,000.00 but less than \$5,000,000.00 the contractor shall obtain the coverage limits as listed for contracts below \$100,000.00 and General Aggregate and Products – Commercial Operations Limit of not less than \$2,000,000.00.

3. Coverage for Comprehensive General Bodily Injury Liability Insurance for a contract over \$5,000,000.00 is:

Each Occurrence	\$2,000,000.00
General Aggregate Limits	\$4,000,000.

(other than products – commercial operations)	
Products – Commercial Operations limit	\$4,000,000.00
Personal and Advertising Injury Limit	\$2,000,000.00
Fire Damage Limit (any one fire)	\$50,000.00
Medical Expense Limit (any one Person)	\$5,000.00

4. For all Contracts – Automobile Liability: in the event that services delivered pursuant to this contract involve the use of vehicles or the transportation of clients, automobile liability insurance shall be required. If Contractor-owned personal vehicles are used, a Business Automobile Policy covering at a minimum Code 2 “owned autos only” must be secured. If Contractor employee’s vehicles are used, the Contractor must also include under the Business Automobile Policy Code 9, coverage for non-owned autos. The minimum limits for automobile liability is: \$1,000,000.00 per occurrence, using a combined single limit for bodily injury and property damage.
5. For Contracts for Hazardous Substance Removal (Asbestos Abatement, PCB Abatement, etc.)
 - a. In addition to providing insurance coverage for the project as outlined above, the Contractor shall provide Pollution Liability insurance for the hazardous substance removal as follows:

<u>EACH OCCURRENCE</u>	<u>AGGREGATE</u>
\$500,000.00	\$1,000,000.00

or \$1,000,000.00 each occurrence/aggregate bodily injury and property damage combined single limit.

- 1) Insurance certificate must state that the insurer is covering hazardous substance removal.
- 2) Should this insurance be secured on a “claims made” basis, the coverage must be continuously maintained for one year following the project’s “final completion” through official completion of the project, plus one year following.

For Contracts where hazardous substance removal is a subcomponent of contracted work, the general contractor shall provide to the Owner a certificate of insurance for coverage as defined in 5a. above. The State of Washington must be listed as an additional insured. This certificate of insurance must be provided to the Owner prior to commencing work.

2.04 Replaces Section 2.04 - PAYMENT AND PERFORMANCE BONDS

Conditions for bonds: Payment and performance bonds for 100% of the Contract Award Amount, plus state sales tax, shall be furnished for the Work, using the Payment Bond and Performance Bond form published by and available from the American Institute of Architects (AIA) – form A312. Prior to execution of a Change Order that, cumulatively with previous Change Orders, increases the Contract Award Amount by 15% or more, the Contractor shall provide either new payment and performance bonds for the revised Contract Sum, or riders to the existing payment and performance bonds increasing the amount of the bonds. The Contractor shall likewise provide additional bonds or riders when subsequent Change Orders increase the Contract Sum by 15% or more.

No payment or performance bond is required if the Contract Sum is \$150,000 or less and the Contractor or General Contractor/Construction Manager agrees that Owner may, in lieu of the

bond, retain 10% of the Contract Sum for the period allowed by RCW 39.08.010.

3.02 Replaces Section 3.02 B – CONSTRUCTION SCHEDULE

B. Form of Progress Schedule: The Progress Schedule shall be in the form of a Critical Path Method (CPM) logic network or, with the approval of the Owner, a bar chart schedule may be submitted. The scheduling of construction is the responsibility of the Contractor and is included in the contract to assure adequate planning and execution of the work. The schedule will be used to evaluate progress of the work for payment based on the Schedule of Values. The schedule shall show the Contractor's planned order and interdependence of activities, and sequence of work. As a minimum the schedule shall include:

1. Date of Notice to Proceed;
2. Activities (resources, durations, individual responsible for activity, early starts, late starts, early finishes, late finishes, etc.);
3. Utility Shutdowns;
4. Interrelationships and dependence of activities;
5. Planned vs. actual status for each activity;
6. Substantial completion;
7. Punch list;
8. Final inspection;
9. Final completion, and
10. Float time

The Schedule Duration shall be based on the Contract Time of Completion listed on the Bid Form. The Owner shall not be obligated to accept any Early Completion Schedule suggested by the Contractor. The Contract Time for Completion shall establish the Schedule Completion Date.

If the Contractor feels that the work can be completed in less than the Specified Contract Time, then the Surplus Time shall be considered Project Float. This Float time shall be shown on the Project Schedule. It shall be available to accommodate changes in the work and unforeseen conditions.

Neither the Contractor nor the Owner have exclusive right to this Float Time. It belongs to the project.

5.01 Replaces Section 5.01 B & D - CONTRACTOR CONTROL AND SUPERVISION

- B. Competent Superintendent required: Performance of the Work shall be directly supervised by a competent superintendent who has authority to act for Contractor. The superintendent must be satisfactory to the Owner and shall not be changed without the prior written consent of Owner. Owner may require Contractor to remove the superintendent from the Work or Project site, at no cost to the Owner for delay or any other claim, if Owner reasonably deems the superintendent incompetent, negligent, or otherwise objectionable, provided Owner has first notified Contractor in writing and allowed a reasonable period for transition. Noncompliance with the Owner's request to remove and replace the superintendent for a material reason shall also be grounds for terminating the Contract for cause.
- D. Contractor to employ competent and disciplined workforce: Contractor shall enforce strict discipline and good order among all of the Contractor's employees and other persons performing the Work. Contractor shall not permit employment of persons not skilled in tasks assigned to them. Contractor's employees shall at all times conduct business in a manner which assures fair, equal, and nondiscriminatory treatment of all persons. Owner may, by

written notice, require Contractor to remove from the Work or Project site, at no cost to the Owner for delay or any other claim, any employee Owner reasonably deems incompetent, negligent, or otherwise objectionable. Noncompliance with the Owner's request to remove and replace personnel at any level for a material reason shall also be grounds for terminating the Contract for cause.

5.02 Replaces Section 5.02 B – PERMITS, FEES AND NOTICES

- B. Allowances for permit fees: The actual cost of the general building permit (only) and the public utility hook-up fees will be a direct reimbursement to the Contractor or paid ***directly to the permitting agency by the Owner. Fees for these permits should not be included by the Contractor in his bid amount***

Add New Section 5.02 D – PERMITS, FEES, AND NOTICES

- D. Contractor to submit copies: The General Contractor shall submit copies of each valid permit required on the project to the Owner's representative. Nothing in this part shall be construed as imposing a duty upon the Owner or A/E to secure permits.

5.04 Replaces 5.04, Section A – PREVAILING WAGES

- A. Contractor to pay Prevailing Wages or applicable Federal Wages: Contractor shall pay the prevailing rate of wages to all workers, laborers, or mechanics employed in the performance of any part of the Work in accordance with RCW 39.12 and the rules and regulations of the Department of Labor and Industries. The schedule of prevailing wage rates for the locality or localities of the Work, is determined by the Industrial Statistician of the Department of Labor and Industries. It is the Contractor's responsibility to verify the applicable prevailing wage rate. If applicable, the Contractor shall comply with all Federal Funding requirements of the Davis Bacon Act that will be addressed in a separate "DIVISION 00 SPECIAL CONDITIONS" specification section that will be based on the specific requirements of the funding source. .

5.04 Replaces 5.04, Section G – Certified Payrolls

- G. Certified Payrolls: Consistent with WAC 296-127-320, the Contractor and any subcontractor shall submit a certified copy of payroll records if requested. If applicable, the Contractor shall comply with all Federal Funding requirements of the Davis Bacon Act that will be addressed in a separate "DIVISION 00 SPECIAL CONDITIONS" specification section that will be based on the specific requirements of the funding source.

5.06 Replaces 5.06, Section A – NONDISCRIMINATION

- A. Discrimination prohibited by applicable laws: The Contractor and all Subcontractors shall comply with all applicable federal and state non-discrimination laws, regulations, and policies. No person shall, on the grounds of age, race, creed, color, sex, sexual orientation, religion, national origin, marital status, honorably discharged veteran or military status, or disability (physical, mental, or sensory) be denied the benefits of, or otherwise be subjected to discrimination under any project, program, or activity, funded, in whole or in part, under this Agreement.

5.07 Replaces 5.07, Section A – SAFETY PRECAUTIONS

- A. In performing this contract, the Contractor shall provide for protecting the lives and health of employees and other persons; preventing damage to property, materials, supplies, and equipment; and avoid work interruptions. For these purposes, the Contractor shall:
1. Follow Washington Industrial Safety and Health Act (WISHA) regional directives and provide a site-specific safety program that will require an accident prevention and hazard analysis plan for the contractor and each subcontractor on the work site. The Contractor shall submit a site-specific safety plan to the Owner's representative prior to the initial scheduled construction meeting.
 2. Provide adequate safety devices and measures including, but not limited to, the appropriate safety literature, notice, training, permits, placement and use of barricades, signs, signal lights, ladders, scaffolding, staging, runways, hoist, construction elevators, shoring, temporary lighting, grounded outlets, wiring, hazardous materials, vehicles, construction processes, and equipment required by all applicable state, federal, and local laws and regulations.
 3. Comply with the State Environmental Policy Act (SEPA), Clean Air Act, Shoreline Management Act, and other applicable federal, state, and local statutes and regulations dealing with the prevention of environmental pollution and the preservation of public natural resources.
 4. Post all permits, notices, and/or approvals in a conspicuous location at the construction site.
 5. Provide any additional measures that the Owner determines to be reasonable and necessary for ensuring a safe environment in areas open to the public. Nothing in this part shall be construed as imposing a duty upon the Owner or A/E to prescribe safety conditions relating to employees, public, or agents of the Contractors.

5.20 Add New Paragraph A. 6. – SUBCONTRACTORS AND SUPPLIERS

6. Within the three-year period immediately preceding the date of the bid solicitation, not have been determined by a final and binding citation and notice of assessment issued by the department of labor and industries or through a civil judgment entered by a court of limited or general jurisdiction to have willfully violated, as defined in RCW 49.48.082, any provision of chapter 49.46, 49.48, or 49.52 RCW.

5.20 Replace Paragraph B – SUBCONTRACTORS AND SUPPLIERS

- B. Use qualified Subcontractors: Contractor shall utilize Subcontractors and suppliers, which are experienced and qualified, and meet the requirements of the Contract Documents, if any. Contractor shall not utilize any Subcontractor or supplier to whom the Owner has a reasonable objection, and shall obtain Owner's written consent before making any substitutions or additions.

7.02 Replace Paragraph B.7.c – CHANGE IN THE CONTRACT SUM, Change Order Pricing – Fixed Price, Components of Increased Cost

- c. Equipment costs: This is an itemization of the type of equipment and the estimated

or actual length of time the construction equipment appropriate for the Work is or will be used on the change in the Work. Costs will be allowed for construction equipment only if used solely for the changed Work, or for additional rental costs actually incurred by the Contractor. Equipment charges shall be computed on the basis of actual invoice costs or if owned, from the current edition of one of the following sources:

- (1) The National Electrical Contractors Association for equipment used on electrical work.
- (2) The Mechanical Contractors Association of America for equipment used on mechanical work.
- (3) The Equipment Watch Fleet Manager Estimator Package (digital). The maximum rate for standby equipment shall not exceed that shown in the Associated General Contractors Washington State Department of Transportation (AGC WSDOT) Equipment Rental Agreement, current edition on the Contract execution date.

10.11 Add Part 10.11 – DIVERSE BUSINESS PARTICIPATION

The state of Washington encourages participation in all of its contracts by Diverse Businesses as found in RCW Chapters 39, 43, and WAC 326. The voluntary Diverse Business goal of 26%, which is an aggregate of: 10% Minority Business Enterprises (MBE), 6% Women Business Enterprises (WBE), 5% Veteran-owned Business, and 5% Washington Small Businesses self-identified in the Washington Electronic Business Solution (WEBS) <http://www.des.wa.gov/services/ContractingPurchasing/Business/Pages/WEBSRegistration.aspx>. Contractors are encouraged to meet or exceed the project goals in the advertisement by any level of participation, regardless of category.

DES reserves the right to adjust the voluntary participation goals.

Businesses are encouraged to register in WEBS, as well as registering as a state certified M/WBE/Veteran Business.

For reporting, Contractor is required to register and create an account in the DES Diversity Compliance Program (B2GNow) at <https://des.diversitycompliance.com/>.

Every month for the duration of your contract, and while your contract is active in the B2Gnow system, submit and accurately maintain the following information through B2Gnow:

- a. Payments received by the prime contractor from the Agency
- b. Payments paid to each first tier subcontractor
- c. Payments paid to each first tier supplier

You must also ensure the following information is reported in the B2Gnow system by your first tier subcontractors and suppliers for the duration of your contract:

- a. Confirmation of payments from the prime contractor to the first tier subcontractor
- b. Confirmation of payments from the prime contractor to first tier suppliers

10.12 Add Part 10.12 - MINIMUM LEVELS OF APPRENTICESHIP PARTICIPATION

In accordance with RCW 39.04.320, the State of Washington requires 15% apprenticeship participation for projects estimated to cost one million dollars or more.

- A. Apprenticeship participation, under this contract, may be counted towards the required percentage (%) only if the apprentices are from an apprenticeship program registered and approved by the Washington State Apprenticeship and Training Council (RCW 49.04 and WAC 296-05).
- B. Bidders may contact the Department of Labor and Industries, Specialty Compliance Services Division, Apprenticeship Section, P.O. Box 44530, Olympia, WA 98504-4530 by phone at (360) 902-5320, and e-mail at Apprentice@Lni.wa.gov, to obtain information on available apprenticeship programs.
- C. For each project that has apprentice requirements, the contractor shall submit a **“Statement of Apprenticeship and Journeyman Participation”** on forms provided by the Department of Enterprise Services, with every request for progress payment. The Contractor shall submit consolidated and cumulative data collected by the Contractor and collected from all subcontractors by the Contractor. The data to be collected and submitted includes the following:
 11. Contractor name and address
 12. Contract number
 13. Project name
 14. Contract value
 15. Reporting period “Beginning Date” through “End Date”
 16. Name and registration number of each apprentice by contractor
 17. Total number of apprentices and labor hours worked by them, categorized by trade or craft
 18. Total number of journeymen and labor hours worked by them, categorized by trade or craft
 19. Cumulative combined total of apprentice and journeymen labor hours
 20. Total percentage of apprentice hours worked
- D. No changes to the required percentage (%) of apprentice participation shall be allowed without written approval of the Owner. In any request for the change, the Contractor shall clearly demonstrate a good faith effort to comply with the requirements for apprentice participation.
- E. Any substantive violation of the mandatory requirements of this part of the contract may be a material breach of the contract by the Contractor. The Owner may withhold payment pursuant to Part 6.05, stop the work for cause pursuant to Part 3.04, and terminate the contract for cause pursuant to Part 9.01.

10.13 Add Part 10.13 – SPECIAL CONDITIONS

The Owner may have Federal Funding or other special requirements for this project. If applicable, the Contractor will be required to comply with the “DIVISION 00 SPECIAL CONDITIONS” section in the specifications that will be based on the specific requirements of the funding source.

00 7400 MODIFICATIONS TO THE GENERAL CONDITIONS

These Central Washington University Modifications to the General Conditions form a part of, and are incorporated in the Contract Documents and modify, delete, add, and replace provisions of the General Conditions. Provisions not altered remain in effect. All terms defined elsewhere in the Contract Documents shall have the same meaning here.

PART 1 - GENERAL PROVISIONS

- 1.01A Modify the sentence as follows:
"Application for Payment" means a written request submitted by contractor to Owner for payment of Work.

PART 2 - INSURANCE AND BONDS

- 2.01 Add the following:
The certificate holder shall be:
Central Washington University
Vice President for Business &
Financial Affairs
Ellensburg, WA 98926

PART 4 - SPECIFICATIONS, DRAWINGS, AND OTHER DOCUMENTS

- 4.01 Add to paragraph 4.02B
...changes and shall be available to Owner and A/E at all times.

PART 5 - PERFORMANCE

- 5.01 Add a new paragraph
G. Work During
Off Hours
When work is to be performed during other than normal working hours or on Central Washington University holidays, Contractor shall give Owner 48 hour prior notice so that Owner's Police Department may be properly notified. Any construction activity between the hours of 7:00 p.m. to 7:00 a.m. PST is subject to approval of Owner.
- 5.02 Add a new paragraph 5.02E
E. Prior to Final Completion, the building permit and City-approved drawings, signed inspection card(s), and any appropriate occupancy permits shall be submitted to Owner.

PART 6 - PAYMENTS AND COMPLETION

- 6.02 Add a new subparagraph:
This schedule shall be based upon any cost loading required as a part of the progress schedule and shall allocate at least 1% of the contract sum (in addition to the statutory retainage described in Paragraph 6.06 to that portion of the work between Substantial and Final Completion.
- 6.03D Add a new subparagraph 6.03D(9):
9 For material stored off-site not in a warehouse, Contractor may request payment, provided that the remaining requirements of this paragraph and any additional requirements of Owner are met.
- 6.04 A In the first sentence change "30 days" to "45 days".
- 6.05B Add the following:
Final Acceptance: Final Acceptance of the Work shall be by action of the Board of Trustees or its delegated representative.

PART 8 - CLAIMS AND DISPUTE RESOLUTION

8.01 Add new Paragraphs 8.01 G and 8.01 H:

- G Notwithstanding 8.02 below, upon request by Owner, any claims between Owner and Contractor, Architect/Engineer and Contractor, Owner and Architect/Engineer, Owner and Contractor's Guarantor, or Contractor and its Subcontractors and Suppliers shall be submitted in a single forum and Owner may consolidate or join any of the above-named parties in the action. Other parties may be joined upon notice by either Contractor or Owner with the consent of such third party.
Thereafter, such third parties shall be bound by the results of such dispute resolution process to the same extent as the original parties to the dispute.
- H Contractor agrees that any contract with a Sub-contractor to perform any portion of the work shall include a provision which contractually requires the Sub-contractor be joined, at the Owner's request, in the dispute process.

8.02 Replace the 8.02 A – E with the following:

- DISPUTE RESOLUTION: In order to assist in the resolution of disputes or claims arising out of the work of this project, the Owner has provided for the following procedures in an escalating fashion.
- A Within 20 calendar days after receipt of a written directive from the Owner's Project Manager to proceed with the protested work, in accordance with Paragraph 8.01. D, the Contractor shall, if the Contractor still objects to such instruction, file a written protest with the Owner's Director of Facilities Management, clearly detailing all of the following:
 1. The basis of the objection(s), and
 2. The contract provisions that support the protest, and
 3. The actual or estimated dollar cost, if any, of protested work and how that cost was determined, and,
 4. Estimates or actual amounts of additional time incurred, if any.
 - B Within 20 calendar days of receipt of the contractor's appeal for review, the Owner shall arrange a meeting to include the Contractor's Senior Principal (or their designee) and the Owner's Business Manager (or his designee). Such meeting shall be held at a mutually agreed time on the Owner's Campus. Either party may request a Mediator be retained to participate in the dispute resolution process. Both must agree on the choice and share equally in the expense. If in disagreement, the parties agree to allow an independent third party such as the Yakima Dispute Resolution Center to pick one.
 - C If the Owner and the Contractor are able to resolve their dispute through this process, the Owner will promptly process any contract changes, otherwise the Owner shall, after review of all the pertinent facts, make a written determination of the dispute and such determination shall be final.
 - D If the Contractor disagrees with the final determination of the Owner, the Contractor may, within 45 calendar days, file a Complaint which shall be subject to judicial review as provided under State of Washington case law, in the Superior Court of Kittitas County, Washington, which shall have exclusive jurisdiction and venue over all matters in question between the Contractor. Failure to file such Complaint within the time prescribed shall be deemed acceptance by the Contractor.

PART 10 - MISCELLANEOUS PROVISIONS

10.11 Change to read as follows:

10.11 W/MBE PARTICIPATION

Goals

CWU encourages participation in all of its contracts by Diverse Businesses as found in RCW Chapters 39, 43, and WAC 326. The voluntary Diverse Business goal of 26%, which is an aggregate of: 10% Minority Business Enterprises (MBE), 6% Women Business Enterprises (WBE), 5% Veteran-owned Business, and 5% Washington Small Businesses self-identified in the Washington Electronic Business Solution (WEBS). Contractors are encouraged to meet or exceed the project goals in the advertisement by any level of participation, regardless of category.

If Contractor has been unsuccessful in complying with these goals for any craft, Contractor shall broaden recruitment, training and job referral opportunities for minorities and women by undertaking each of the following:

- 1 Notify Owner;
- 2 Notify state and community organizations of opportunities for employment, and retain evidence of their responses. Trade associations maintain lists of community organizations that refer minority and women workers for employment in construction trade;
- 3 Maintain a file in which is recorded the name and address of each minority and woman worker referred to Contractor and specifically what action was taken with respect to each such referred worker. If such worker was not employed by Contractor, Contractor's file shall document this and the reason therefore;
- 4 Notify Owner whenever the union with which Contractor has a collective bargaining agreement has not referred to Contractor a minority or woman worker requested by Contractor, or Contractor has other information that the union referral process has impeded Contractor's efforts to effect minority or women utilization. Contractor shall show what relief has been sought under the collective bargaining agreement or through appropriate federal and state agencies. Appropriate steps can include, but are not limited to, arbitration or administrative relief;
- 5 Hire directly on a non-discriminatory basis for performance of Work, if a court of competent jurisdiction finds that a union with which Contractor has a collective bargaining agreement racially or sexually discriminates in recruitment or dispatch of worker; and
- 6 Use of apprentices or other appropriate entry classifications up to limits allowed or required by applicable collective bargaining agreements to meet the goals.

B Reports

Contractor shall report monthly the total hours of employment on site by craft and category. Reports will be submitted on the form attached to this Section titled "Affidavit of Amount Paid MBA/WBE".

C Compliance Meetings

Upon Owner's request, Contractor and Owner will hold a conference to discuss affirmative action with regard to equal employment opportunity. Review will be made of Contractor's reports and evidence of good faith efforts.

D Definitions

- 1 "Minority is defined as Blacks, Asians (Japanese, Chinese, Filipino), American Indians, Spanish-Americans (includes Mexican-American, Puerto Rican and other people with Spanish surnames not otherwise reported) and other (including Korean, Polynesian, Indonesian, Hawaiian, Aleut, and Eskimo).
- 2 "Craft" is defined as a recognized construction trade for which minimum wage categories are established by the Department of Labor and Industries.

10.14 Add the Following:

10.14 ASBESTOS

A Asbestos Products

Contractor shall ensure that no Asbestos products in any form are incorporated into the Work.

B Good Faith Inspection

- 1 Owner has performed a good faith inspection to determine whether the materials to be worked on or removed contain Asbestos, and will make this inspection report available to all bidders. Contractor shall not commence Work without receiving a copy of this report.
- 2 Contractor shall keep the asbestos inspection report on site.
- 3 The usual policy of the Owner is to identify and abate Asbestos before the Work begins, unless Asbestos abatement is included in the scope of Work of these Contract Documents. In limited cases where Owner is reasonably certain that Asbestos will not be disturbed, Asbestos material are to remain intact in the work area. These materials would be identified in the Asbestos inspection report and Contractor advised of protective measures.

- 4 In some cases, where certain construction or demolition tasks must be performed before the Asbestos can be accessed for removal, or where phasing of the construction does not permit scheduled during the Contract Time. In such cases, Owner and Contractor must coordinate the scheduling of the work of the separate Asbestos contractor.
- C Notice
If in the course of performing the Work Contractor encounters an Asbestos Project which was not specifically reference in the Contract Documents, or disturbs Asbestos, Contractor shall immediately stop work and notify Owner. Contractor shall not recommence work until authorized by Owner.
- D Delays
Owner will use its best efforts to identify the scope of an Asbestos Project in the Contract Documents. Contractor acknowledges that the condition or scope of an Asbestos Project cannot be fully determined if it would result in disturbance or exposure of asbestos prior to undertaking the Work. If Contractor is significantly delayed during the course of performance because of the presence of Asbestos not identified in the Contract Documents, Contractor may request an equitable adjustment in the Contract Sum in accordance with the provisions of section 7.02.
- E Permits
Contractor shall file a Notice of Intent to Remove Asbestos with the Department of Labor and Industries. Prior to submitting such notice to the Department of Labor and Industries, Contractor shall submit for approval to Owner Contractor's proposed procedures for undertaking the Asbestos Project to assure compliance with Owner's performance standards and applicable regulations.
- F Safety Precautions
Contractor shall provide, at Contractor's cost, appropriate clothing, caution sign, supply items, and safety equipment in order to perform the Asbestos Project in accordance with the Regulations and the performance standards of Owner.
During the course of performing an Asbestos Project, Contractor shall monitor the work place and adjacent areas in accordance with the regulations and the performance standards of Owner to ensure that permissible levels of airborne concentrations of asbestos fibers are not exceeded. The results of all monitoring shall be immediately provided to Owner. If the prescribed exposure limits are exceeded, Contractor shall immediately execute a compliance program of engineering and work practices approved by Owner.
- G Certification
No Contractor or person shall undertake an Asbestos Project unless certified by the Department of Labor and Industries as a qualified asbestos contractor, supervisor, or worker in accordance with the requirements of WAC Chapter 296-65.
- H Records
Contractor shall maintain complete records of personal and environmental monitoring. A copy of these records shall be provided to Owner before Final Acceptance. Contractor is also required by regulation to arrange for medical examinations for those employees who work on an Asbestos Project and to maintain those records for at least twenty years.
- I Definitions
 - 1 "Asbestos" includes different forms of chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.
 - 2 "Asbestos Project" means the construction, demolition, repair, maintenance or renovation of any building, mechanical piping equipment or system involving the demolition, removal, encapsulation, salvage, or disposal of material which may release asbestos fibers into the air.
 - 3 "Regulations". For purpose of this section Regulations shall mean the National Emission Standards for Hazardous Air Pollutants (40 CFR 61), Occupational Safety and Health Requirements Pertaining to Asbestos (29 CFR 1910), the Regulations of the Washington State Department of Labor and Industries, WAC Chapters 296-62, -65, -155, and Puget Sound Air Pollution Control Agency (PSAPCA) regulating Asbestos Projects as adopted or hereafter amended.

Attachment: "Affidavit of Amounts Paid MBE/WBE Participants"

END OF SECTION

AFFIDAVIT OF AMOUNTS PAID MBE/WBE PARTICIPANTS
(provide report monthly with each application for payment)

CONTRACTOR: _____ ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____ DATE: _____

STATE CONTRACT/AGREEMENT NO. JOB TITLE/DESCRIPTION _____

CONTRACT BID PRICE MBE COND. OF AWARD _____ WBE COND. OF AWARD _____

MBE/WBE PARTICIPANT NAME AND ADDRESS	WBE	MBE UTILIZATION	DESCRIPTION OF PARTICIPANTS	AMOUNT PAID
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AFFIDAVIT

I, the undersigned, do hereby certify that in connection with all work for the project for which this statement is submitted each MBE/WBE participant contacted by me has been paid the amounts as listed. \$ _____
TOTAL WBE PARTICIPATION ACHIEVED

SIGNATURE _____ TITLE _____

Subscribed and sworn to me this _____ day of 20_ _____
Notary Public in and for the State of Washington residing
at _____

INSTRUCTIONS:

1. Complete this form in triplicate and have it notarized.
2. This form is required to be updated monthly and provided with each payment request from the General Contractor.

SECTION 01 0100 - SUMMARY OF WORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following:

1. Work covered by the Contract Documents.
2. Type of Contract.
3. Permits, Fees and Bonds.
4. Work sequence
5. Owner's occupancy requirements.
6. Contractor Use of Site and Premises.
7. Work restrictions.

B. Related Sections include the following:

1. Division 1 Section "Temporary Facilities and Controls" for limitations and procedures governing temporary use of Owner's facilities.

1.2 RELATED DOCUMENTS

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

1.3 PROJECT

A. Project Name: Samuelson Data Center AHU Replacement

1. Owner's Name: Central Washington University
2. Engineers Name: MW Consulting Engineers
3. The Project consists of the following:

- a. Project schedule coordination with CWU Facilities.
- b. Removal of existing air handling unit as described in drawings.
- c. Installation of new air handling unit and pumped chilled water cooling system.
- d. Drawings indicate a future (phase 2) air handler replacement with a DX cooling coil and rooftop condensing unit.

1.4 CONTRACT DESCRIPTION

- A. Contract Type: Single General Construction Contract based on a single lump-sum price as described in Division 00.

1.5 PERMITS, FEES AND BONDS

- A. The Owner will apply for and obtain a general building permit from the City of Ellensburg, if applicable.
- B. Any other permits and fees necessary for the execution of this work shall be obtained and paid for by the Contractor.

1.6 WORK SEQUENCE

- A. The work will be a single project with installation occurring as necessary for the scope.
- B. The Contractor shall schedule and supervise the work to minimize the time for each phase, to allow for Owner relocations between phases, and to accomplish completion of all phases within the contract time indicated.
- C. The Contractor shall schedule any work that impairs Owner's adjacent facility operations to after hours or weekends and only as approved by Owner.

1.7 OWNER OCCUPANCY

- A. The subject building will be fully occupied during the period established for the work of this contract. The Owner will vacate the area of the work in phases as coordinated with Contractor.
- B. Cooperate with Owner to minimize conflict and to facilitate Owner's operations. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and authorities having jurisdiction.
- C. Adjacent work by others: The Owner will be executing other construction work on the campus simultaneous to the work of this contract.

1.8 CONTRACTOR USE OF SITE AND PREMISES

- A. Construction Operations: Limited to areas noted on Drawings.
 - 1. Contractor's use of the premises will not impede or otherwise impact the work of other contractors and/or work adjacent to the project site.
- B. Arrange use of site and premises to allow:
 - 1. Work by Others.
 - 2. Work by Owner.
- C. Provide access to and from site as required by law.

1. Emergency Building Exits During Construction: Keep all exits required by code open during construction period; provide temporary exit signs if exit routes are temporarily altered.
2. Do not obstruct roadways, sidewalks, or other public ways without permit.

1.9 WORK RESTRICTIONS

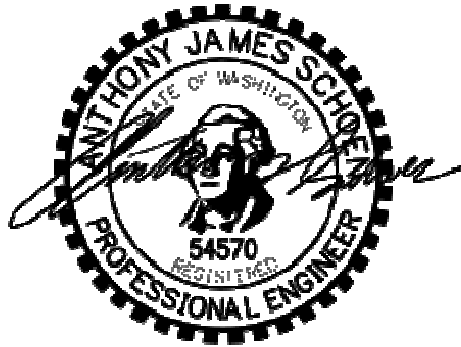
- A. Hours of Operation: 7:00 am - 6:00 pm, Monday – Friday (5) days per week, unless otherwise agreed upon by CWU Project Manager.
- B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.
 1. Provide Owner not less than 72 hours' notice in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Owner's written permission.

PART 2 - NOT USED

PART 3 - NOT USED

END OF SECTION 01 0100

MECHANICAL CONTRACT SPECIFICATIONS DIVISION 23



7-14-2025

The Engineer's seal and signature affixed hereon is all inclusive for the full content of this portion of the document

SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 CONDITIONS AND REQUIREMENTS

- A. Refer to Divisions 00 & 01 of these specifications, which govern work under Division 23. Refer to other sections of these specifications for additional related requirements.

1.2 SCOPE OF REQUIREMENTS

- A. The work covered by Division 23 of the specifications (HVAC/Mechanical) shall include but not limited to furnishing all materials and supplying all labor, equipment, and services to install the complete mechanical systems as shown on the accompanying drawings and specified herein.
- B. Work done under Division 23 of the specifications shall comply with the requirements specified herein.

1.3 ALTERNATES

- A. The bid price for each alternate shall include a complete working Division 23 system as described in the alternates, shown on the drawings, and indicated in these specifications.

1.4 CODES, PERMITS AND FEES

- A. Division 23 work shall be in accordance with the following as adopted by the governing agencies, including amendments:
 - 1. Americans with Disabilities Act (ADA)
 - 2. Applicable State and Local Codes and Ordinances
 - 3. National Electrical Code
 - 4. International Building Code
 - 5. International Fire Code
 - 6. International Mechanical Code
 - 7. Uniform Plumbing Code
 - 8. Washington State Non-Residential Energy Code
- B. Permits and inspections required for the Division 23 work on this project shall be obtained as part of the Division 23 scope of work, and the cost for these permits and inspections shall be included in the Division 23 bid. All inspection certificates shall be delivered to the Owner's Representative prior to final acceptance of the work in accordance with the requirements of these specifications.
- C. All costs levied by utility companies and/or governing agencies shall be included in the Division 23 scope of work and shall be included in the Division 23 bid.

- D. Work shall comply with all regulations associated with all applicable utilities.

1.5 INTENT AND INTERPRETATIONS

- A. It is the intent of these plans and specifications to result in a complete and working Division 23 installation in complete accordance with all applicable codes and ordinances.
- B. The drawings and these specifications are intended to supplement each other. Any details contained in either the drawings or these specifications shall be included as if contained in both.
- C. Items not specifically mentioned in the specifications or noted on the drawings, but which are obviously necessary to make a complete working installation shall be included.

1.6 DEFINITIONS

- A. The term "Acceptance", when used in Division 23, shall be defined as the Owner's assumption of ownership for part or all of the Division 23 system. Acceptance of part or all of the Division 23 system, when granted prior to completion of Division 23 work and/or correction of deficiencies, shall not relieve Division 23 of any responsibility for completion of this work and/or correction of these deficiencies.
- B. The term "Date of Acceptance", when used in Division 23, shall be the official date when Acceptance, as defined in these specifications, occurs. The Date of Acceptance shall be assumed to coincide with granting of Substantial Completion unless noted otherwise by the Owner's Representative. Deviation of the Date of Acceptance from Substantial Completion can assume to have occurred only when written documentation is provided by the Owner's Representative specifically indicating this separation and identifying an alternative designation for the Date of Acceptance.
- C. The terms "The Contractor" or "This Contractor", when used, shall be defined as the Contractor responsible for Division 23 work.
- D. The term "Owner's Representative", when used, shall refer to the Engineer or his designated representative in accordance with Division 23.
- E. The term "Provide" shall mean furnish and install.
- F. The term "HVAC" or "Mechanical", when used, to distinguish a particular scope of work or portion of the documents, shall mean the Division 23 scope of work and Division 23 documents (drawings and specifications) respectively.

1.7 DRAWINGS

- A. HVAC and Mechanical drawings show general arrangement of piping, ductwork, equipment, etc. Drawings shall be followed as closely as actual building construction and work of other trades will permit.

- B. Structural drawings and specifications shall be considered part of this work insofar as they furnish information relating to design and construction of the building. These documents take precedence over Division 23 drawings and specifications if any dimensional discrepancies exist.
- C. Drawings are diagrammatic only. Consequently, all required duct and pipe offsets are not indicated on the drawings. Offsets as required to meet the design intent of the drawings shall be provided.

1.8 GUARANTEE

- A. The Division 23 equipment, materials, and installation shall be guaranteed for a period of one (1) year unless an individual item or specification is otherwise noted as longer. All defects in Division 23 work and/or equipment furnished that develop at any time during the one year guarantee period shall be corrected at no cost to the owner, including any expenses for cutting, patching, and repairing made necessary by corrections of unsatisfactory work and/or damage resulting from incorrect equipment operation.
- B. The guarantee period shall begin upon the Date of Acceptance. When Acceptance is granted for portions of the Division 23 system at different times, the guarantee for each portion of the Division 23 system shall begin upon Acceptance of that portion of the Division 23 system.
- C. Permission to use the permanent Mechanical system for temporary heating during construction does not constitute acceptance. All product and system warranties shall be extended at no cost to the Owner as required to maintain this one (1) year requirement from the Date of Acceptance if such permission is given.
 - 1. Exception: Use of part or all of the Division 23 system prior to the Date of Acceptance, when initiated by the Owner, shall constitute Acceptance of the specific piece of equipment and/or portion of the system only when acknowledgement of Acceptance is noted in written authorization from the Owner as required in these specifications.
- D. Equipment warranties in addition to this guarantee shall be provided in accordance with the table at the end of this section.

1.9 FILTERS

- A. Refer to paragraph "Use of Equipment During Construction" Section 230500.
- B. New filters shall be installed prior to system startup.
- C. If systems are operated prior to testing, adjusting, and balancing (TAB), new filters shall be installed prior to starting (TAB) work.
- D. Filters in portions of Division 23 systems that are completed and used prior to overall project substantial completion shall be changed as required to protect the Division 23 systems.
- E. New filters shall be provided at time of overall project substantial completion. In addition, an extra set shall be furnished as additional stock.

1.10 COST BREAKDOWN

- A. Refer to Divisions 00 and 01 for supplemental requirements.
- B. A breakdown of the HVAC construction cost shall be furnished to the Owner's Representative within 30 days of Notice to Proceed, with separate costs for each of the items listed in the cost breakdown in Part 4 of this section.

1.11 PAYMENT REQUESTS

- A. Payment requests for materials and equipment will not be reviewed or approved until submittals and operation and maintenance data have been received and approved.
- B. Payment requests for the Energy Management and Control System (EMCS) will not be reviewed or approved until submittals required under Section 230923 have been received. Once these submittals have been received, only payment requests for programming and submittals will be reviewed until all submittals required under Section 230923 have been reviewed and approved. Payment requests for materials and/or installation will not be reviewed prior to approval of all submittals required under Section 230923.

1.12 USE OF EQUIPMENT DURING CONSTRUCTION

- A. Use of the building permanent systems is not allowed during construction.
- B. The mechanical room and air handling unit equipment shall not be used to store construction or waste materials.
- C. Temporary heating for the facility during the construction phase shall not be supplied by the permanent system installed under Division 23 unless Contractor shall obtain a letter of approval from the Owner stating that they understand equipment expected life may be shortened due to severe usage.
- D. If the Contractor is given permission to use permanent systems for space heating during construction:
 - 1. The Contractor shall be responsible for pressure cleaning all coils and vacuum cleaning all ductwork prior to occupancy if deemed necessary by the Owner's Representative.
 - 2. Product warranties shall be extended as required to account for construction use. Warranty periods offered by equipment manufacturers and/or required by these specifications shall begin at the Date of Acceptance. If equipment manufacturers require that the warranty period begin with use of equipment during construction, the Contractor shall bear the expense of extending all such warranties to maintain the required warranty period beyond the Date of Acceptance.
 - 3. Filters shall be installed meeting the requirements of the drawings and these specifications for the permanent system. Systems which have multiple stages of filtration shall have filters installed meeting the requirements of the drawings and these specifications for the first level of filtration. In addition to the requirements for the permanent system, filters provided during construction shall have a Minimum Efficiency Reporting Value (MERV) rating of 13 whether such a rating is required for the

permanent system or not. New filters shall be installed prior to system balancing. Units shall not be operated without filters in place. Check and change filters at intervals sufficient to protect the Division 23 system.

4. Filter fabric shall be provided at all return grilles subject to airborne construction debris. Filter fabric shall be replaced at intervals sufficient to protect the Division 23 system. Filter fabric shall be removed prior to system balancing.

1.13 SUBMITTALS

- A. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- B. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS – STANDARDS AND CODES

- A. Materials used under this Contract, unless specifically noted otherwise, shall be new and of the latest and most current model line produced by the manufacturer. Outdated "new" equipment is not acceptable. Each item of equipment and material shall conform to the latest Standard Specifications of the American Society for Testing Materials and shall conform to any applicable standards of the United States Department of Commerce.
- B. Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Project is turned over to the Owner.
- C. Motor efficiencies shall meet or exceed the requirements of the applicable energy code.
- D. All electrically driven or connected equipment shall be provided with UL or equivalent label and/or listing in accordance with the requirements of the NEC.
- E. Equipment shall be UL listed as an assembly where listing/labeling program is available for that type of equipment.
- F. All control panels shall be provided with UL or equivalent label and/or listing in accordance with the requirements of the NEC and applicable local electrical codes.
- G. Fuel fired equipment shall be listed by a nationally recognized testing laboratory for use with the particular fuel type.
- H. All pressure vessels and relief valves shall be furnished in accordance with applicable State Boiler and Unfired Pressure Vessel Laws. This shall include rating and stamped in accordance with the ASME Boiler and Pressure Vessel Code where required by Code authorities or State Law.

2.2 EQUIPMENT/MATERIAL SUBSTITUTIONS

- A. Throughout these specifications and drawings, various materials, equipment, apparatus, etc., are specified or scheduled by manufacturer, brand name, type or catalog number. Such designation is to establish standards of desired quality and construction and shall be the basis of design and the bid.
- B. Substitutions will not be permitted without written approval.
- C. Where two or more manufacturer designations are listed in these specifications, choice will be optional with the Contractor except that where more than one manufacturer is listed and only one manufacturer's catalog number is specified or only one manufacturer scheduled on the drawings (basis of design), that standard of quality, dimensional characteristics, capacities, and construction shall be maintained by materials or equipment supplied by the other manufacturer(s).
- D. Substituted equipment with efficiencies less than 95 % of the basis of design efficiency shall not be considered equal to the basis of design.
- E. If the Division 23 Contractor uses manufacturers other than the basis of design, the Contractor shall be responsible for:
 - 1. Insuring the substituted item will fit the available space while allowing proper maintenance access
 - 2. Any changes required by other Contractors caused by the substituted equipment
 - 3. Changes in electrical requirements: See "Equipment Substitutions – Electrical Characteristics" below
 - 4. Changes in structural design due to weight differences
- F. In the event other than specified equipment is used and will not fit job site conditions, this Contractor shall assume responsibility for replacement with items indicated as the basis of design.
- G. Substitutions not approved during bid will not be accepted.

2.3 EQUIPMENT SUBSTITUTIONS – ELECTRICAL CHARACTERISTICS

- A. Products furnished other than the basis of design shall have similar electrical characteristics as the scheduled or specified equipment. The Contractor shall be responsible for any electrical changes caused by products not in accordance with this requirement.

2.4 SUBMITTALS FOR REVIEW

- A. Shop drawings, catalog information and material schedules shall be submitted for approval on all specified materials and equipment in Division 23 prior to ordering.
- B. Provide specific wiring diagrams for all equipment requiring electrical or control wiring. Upon approval, copies of these diagrams shall be forwarded to pertinent contractors.

- C. Furnish complete shop drawing/catalog data for equipment and materials to be used in the work for review. Allow sufficient time for developing shop drawings, processing and review time so that the installation will not be delayed.
- D. Shop drawings shall be reviewed, approved and stamped by the Contractor prior to submitting to Owner's Representative for approval. Submittals without such approval will be returned without review.
- E. Where choices of options and accessories are available or specified, provide written description of what is to be furnished. If necessary, list page numbers where submitted items are described.
- F. State sizes, capacities, brand names, motor horsepower, electrical characteristics, accessories, materials, gauges, dimensions, and other pertinent information.
- G. Underline applicable data.
- H. If material or equipment is not as specified or submittal is not complete, it will be rejected. Only complete submittal including all applicable specification sections will be reviewed.
- I. Field applied adhesives, sealants, fillers, primers, glues, and paint shall have VOC's that are equal to or lower than the requirements as identified in part 3 of this section.
- J. Provide cut sheets and a Material Safety Data Sheet (MSDS) for each field applied sealant, adhesive, coating, paint etc used in the building, highlighting VOC limits and chemical component limits. Also indicated in addition to actual VOC emissions identify allowed limits of each product to demonstrate compliance. Submit all proposed field applied products as a single submittal for review with their MSDS data.
- K. Catalog data or shop drawings for equipment which are noted as being reviewed shall not supersede Contract Documents.
- L. Review comments shall not relieve the Contractor from responsibility for deviations from Contract Documents unless attention has been called to such deviations in writing at time of submission, nor shall they relieve this Contractor from responsibility for errors in items submitted.
- M. Check work described by catalog data with Contract Documents for deviations and errors.
- N. Shop drawings and submittal information shall be provided for all required Division 23 equipment in a single submittal. All Division 23 sections shall have a dedicated submittal and shall include all products with the section. Incomplete submittals will be rejected without review.
 - 1. Exceptions: At the discretion of the Owner's Representative, partial project submittals may be allowed.
- O. Submittal Format:

1. Electronic submittals shall be provided with accordance with all of the following conditions. Electronic submittals which do not comply with all of these conditions will be rejected without review.
 - a. Electronic submittals shall be submitted in the current version of Adobe Portable Document Format (PDF)
 - b. Submittals shall be original PDF's of the document and shall not be created using scanned copies of paper documents.
 - c. PDF documents shall be searchable.
 - d. PDF documents shall be unlocked
 - e. Electronic submittals shall be separated by specification section and identified as such. Submittals which combine multiple sections into a single document will be rejected.
 - f. Electronic submittals shall include a table of contents and each applicable section shall be bookmarked for easy access.
 - g. Electronic submittals shall be clearly marked in RED using boxes and arrows and other appropriate markings to indicate specific product information, option selections, accessories, etc.

- P. Each product shall be keyed to the paragraph number in the specifications.

- Q. Operation and maintenance data for individual equipment shall also be provided subsequent to approval of equipment submittals in a separate binder meeting the same requirements as the submittal binder. Refer to Part 3 of this specification for supplemental requirements.

- R. All submittals and re-submittals as required shall be provided with a cover page incorporating a table similar to that provided at the end of this section. The appropriate box(es) shall be checked on each line item for all submittals.

- S. Field applied adhesives, sealants, fillers, primers, glues, and paint shall meet or exceed the LEED requirements as identified in Division 01 Update with spec number. Provide cut sheets and a Material Safety Data Sheet (MSDS) for each field applied sealant, adhesive, coating, paint etc used in the building, highlighting VOC limits and chemical component limits. Also indicated in addition to actual VOC emissions identify allowed limits of each product to demonstrate compliance.

PART 3 - EXECUTION

3.1 LOCATIONS

- A. Coordination of Division 23 equipment and systems to the available space, with other trades and to the access routes through the construction shall be the Contractor's responsibility.

- B. Drawings are diagrammatic. Make offsets, transitions, and changes in direction of pipes and ducts as required to maintain proper head room and pitch of sloping lines and avoid structural, electrical, pipe and duct interferences whether or not indicated on Drawings. Furnish fittings, etc., as required to make these offsets, transitions and changes in direction at no additional cost to the Owner.

- C. Pipe and duct routing shall be coordinated and verified with all trades prior to fabrication and installation. Additional project costs resulting from failure to do so shall be the Contractor's responsibility.
- D. Determine exact route and location of each pipe and duct and coordinate and obtain approval for changes from the layout indicated on the drawings with the Owner's Representative prior to fabrication.
- E. Locations of equipment and devices, as shown on the drawings, are approximate unless dimensioned. Verify the physical dimensions of each item of Division 23 equipment to fit the available space and promptly notify the Owner's Representative prior to roughing-in if conflicts appear.
- F. All piping, wiring, equipment, ductwork, tubing, etc., shall be concealed within building construction unless otherwise noted, or in Division 23 rooms.
- G. Arrange pipes, ducts, and equipment to permit ready access to valves, unions, traps, trap primers, starters, motors, control components, and to clear openings of doors and access panels.
- H. Existing Utilities and Piping
 - 1. The locations of existing concealed lines and connection points have been indicated as closely as possible from available information. The Contractor shall assume that such connection points are within a 10 foot radius of the indicated location. Where connection points are not within this radius, the Contractor shall contact the Owner's Representative for a decision before proceeding or may proceed at his own expense.
 - 2. Connection points to existing work shall be located and verified prior to starting new work.
 - 3. Prior to commencing any excavation or ditching activity, the Contractor shall verify the exact location and inverts of all existing utilities and connection points in the area of his proposed excavation. Notify the Owner's Representative for further direction if actual inverts will not allow the proper installation of new work.
 - 4. The Contractor shall be responsible for damages which might be caused by his failure to exactly locate and preserve underground utilities.

3.2 SCHEDULING

- A. It is understood that while drawings are to be followed as closely as circumstances permit, the Contractor shall be responsible for installation of systems according to the true intent and meaning of Contract Documents. Anything not clear or in conflict will be explained by making application to Owner's Representative. Should conditions arise where certain changes would be advisable, secure approval from Owner's Representative for those changes before proceeding with work.
- B. The contractor shall coordinate with the work of various trades when installing interrelated work. Before installation of Division 23 items, proper provisions shall be made to avoid interferences. Changes required in work specified in Division 23 caused by neglect to do so shall be made at no cost to Owner.

- C. Supports and inserts in concrete required for Division 23 supports shall be furnished and installed unless otherwise noted. Furnish sleeves, inserts, supports, and equipment that are an integral part of other Divisions of the Work to those involved in sufficient time to be built into construction as the Work proceeds. Locate these items and see that they are properly installed. Expense resulting from improper location or installation of items above shall be borne under Division 23.

3.3 CUTTING AND PATCHING

- A. All cutting and patching of new and existing construction required for the installation of systems and equipment specified in Division 23, including patching of existing walls, floors, and roofs upon removal of existing Division 23 systems and equipment, shall be the responsibility of the Division 23 Contractor. All cutting shall be accomplished with masonry saws, drills or similar equipment to provide neat uniform openings.
- B. Walls, floors, ceilings and roof shall be patched and repaired with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials. All patching shall meet the approval of the Owner's Representative.
- C. All cutting and patching made necessary to repair defective equipment, defective workmanship or be neglect of this Contractor to properly anticipate his requirements shall be included in Division 23.
- D. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses or other structural members without the Owner Representative's written approval.
- E. Cutting, patching, repairing, and replacing pavement, sidewalks, roads, and curbs to permit installation of work specified or indicated under Division 23 is responsibility of Division 23.

3.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Follow manufacturer's directions in delivery, storage, protection, and installation of equipment and materials.
- B. Promptly notify Owner's Representative in writing of conflicts between requirements of Contract Documents and Manufacturer's directions and obtain written instructions from Owner's Representative before proceeding with work. The Contractor shall bear expenses arising from correcting deficiencies of work that do not comply with manufacturer's directions or such written instructions from Owner's Representative.
- C. Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or mechanical injury but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in a dry, heated space.
- D. Notify Owner of equipment delivery dates twenty-four (24) hours in advance of delivery.

- E. The Contractor shall be responsible for protection of equipment furnished in Division 23 from vandalism and weather during all phases of construction. Damaged equipment shall be restored to like new condition or replaced at the Contractor's expense.
- F. Ductwork shall be protected and handled in accordance with SMACNA Intermediate Level of duct cleanliness for new construction. Ductwork shall be stored on pallets off of grade in an area that is clean, dry and exposure to dust is minimized. Internally lined ductwork and air handling equipment shall be kept dry. Internal insulation that has been allowed to become wet will be rejected. Air handling equipment that has been allowed to become wet may be rejected.
- G. Any factory painted equipment scratched or marred during shipment or construction shall be restored to original "new" condition. This includes complete repainting if necessary to provide exact paint match.

3.5 VISITING THE PROJECT SITE

- A. The premises shall be examined and conditions shall be understood which may affect performance of work of Division 23 before submitting proposals for this work.
- B. No subsequent allowance for time or money will be considered for any consequence related to failure to examine existing site conditions.

3.6 TESTS

- A. See individual specification sections for Testing Requirements.

3.7 COMMISSIONING SUPPORT

- A. The equipment and systems referenced in the Related Work section are to be commissioned per Division 23 commissioning specifications. The contractor has specific responsibilities for scheduling, coordination, startup, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.
- B. Include allowance in the bid to support commissioning. Allowance shall be a separate line item on the schedule of values.
- C. Include time for commissioning activities on the construction schedule to complete commissioning prior to substantial completion with the exception of seasonal testing which the commissioning agent determines should coincide with peak heating and cooling weather conditions.
- D. Related Work: All Sections in Division 23.

3.8 CHEMICAL WATER TREATMENT SUPPORT

- A. Prior to water treatment being performed for closed loop systems the Division 23 and 230923 contractors shall provide documentation that all control valves are connected and in operation and verify that all valves are in the open position for complete circulation of cleaning chemical. Documentation shall be provided at the end of each phase of work prior to commencement of the water treatment work.
- B. See Section 232500 for additional water treatment requirements.

3.9 LOW EMITTING MATERIALS

- A. All field applied wet coatings, paints, adhesive and sealants that are installed within the water proofing membrane with Volatile Organic Compounds shall not exceed the limits below.
- B. Allowed limits for architectural coatings per South Coast AQMD Rule 1113 effective February 5, 2016 (g/l):

1.	Mastic Coatings	100
2.	Metallic Pigmented Coatings	150
3.	Multi Color Coatings	250
4.	Non Flat coatings	50
5.	Pre-Treatment Wash Primers	420
6.	Primers/Sealants/Undercoats	100
7.	Reactive Penetrating Sealers	350
8.	Clear Shellac	750
9.	Pigmented Shellac	550
10.	Specialty Primers	100
11.	Water Proofing Sealers	100
12.	Other:	Consult Rule 1113.

- C. Allowed Limits for sealants per South Coast AQMD Rule 1168 effective October 2017 (g/l):

1.	Contact adhesive	350
2.	Edge Glue Adhesive	250
3.	Plastic ABS Welding Cement	325
4.	ABS to PVC transition cement	510
5.	CPVC Welding Cement	490
6.	PVC Welding Cement	510
7.	Other plastic welding cements	250
8.	Foam Insulation	250
9.	Foam Sealant	250
10.	Grout	65
11.	Non Staining plumbing putty	150
12.	Butyl Tapes	250
13.	Fiberglass Duct Liner adhesives	80
14.	Other-Duct Sealants	420
15.	Other sealants:	Consult Rule 1168.

3.10 PROJECT CLOSEOUT/OPERATION AND MAINTENANCE MANUAL

- A. Electronic submittals shall be provided with accordance with all of the following conditions. Electronic submittals which do not comply with all of these conditions will be rejected without review.
1. Electronic submittals shall be submitted in the current version of Adobe Portable Document Format (PDF)
 2. Submittals shall be original PDF's of the document and shall not be created using scanned copies of paper documents.
 3. PDF documents shall be searchable.
 4. PDF documents shall be unlocked
 5. Electronic submittals shall be separated by specification section and identified as such. Submittals which combine multiple sections into a single document will be rejected.
 6. Electronic submittals shall include a table of contents and each applicable section shall be bookmarked for easy access.
 7. Electronic submittals shall be clearly marked in RED using boxes and arrows and other appropriate markings to indicate specific product information, option selections, accessories, etc.
 8. Each product shall be keyed to the paragraph number in the specifications.
- B. Cover page shall include:
1. Job title
 2. Date
 3. Engineer
 4. Contractor
 5. Construction Division
- C. Work shall be done in a print shop or bindery.
- D. Provide a master index at the beginning of the manual showing items included. Use plastic tab indexes for the sections and sub-sections of the manual.
- E. Manual shall be organized into the following five sections:
1. Contacts: This shall consist of name, address, and phone number of the following parties: Mechanical Engineer, Electrical Engineer, General Contractor, HVAC Contractor, Piping Contractor, Sheet Metal Contractor, Temperature Controls Contractor, Sprinkler Contractor, Electrical Contractor and major equipment suppliers.
 2. Equipment
 - a. Begin the Equipment section with a separate sub-section containing a list of the Division 23 equipment indicating:
 - 1) Equipment name and designation as it appears on the equipment schedule
 - 2) Area served
 - 3) Manufacturer
 - 4) Model
 - 5) Serial number
 - 6) Name plate data

- b. The remaining sub-sections shall include, at a minimum, the following for each item of Division 23 equipment. This material shall be organized in a separate tabbed sub-section for each section of the specifications. Within each sub-section, provide separate tabs for each item of equipment, referencing the equipment schedule designation. Provide the following information as applicable:
 - 1) Performance curves or tables showing the specified operating points and the operating points after final testing and balancing
 - 2) Manufacturer's maintenance instructions: Instructions shall include name of vendor, installation instructions, parts numbers and lists, operation instructions of equipment, maintenance and lubrication instructions, troubleshooting guides, and overhaul specifications for major equipment.
 - 3) Step-by-step procedure to follow in putting each piece of Division 23 equipment into operation
 - 4) Wiring diagram for particular equipment item
 - 5) Refer to individual specification sections for additional information required to be incorporated into the Operation and Maintenance Manual.
3. Maintenance Schedule and Spare Parts
 - a. This shall include two sub-sections:
 - 1) The first sub-section shall consist of a preventative maintenance schedule summary table (or list). The table shall be organized by specification section and include:
 - a) Equipment name and designation as it appears on the equipment schedule
 - b) Equipment location
 - c) Type and frequency of preventative maintenance requirements (including lubrication)
 - 2) The second sub-section shall consist of a list of spare parts furnished under this contract. The list shall be organized by specification section and include (similar to that included at the end of this section):
 - a) Equipment name and designation as it appears on the equipment schedule
 - b) Spare part furnished
 - c) Verification by an Owner's Representative that the part(s) have been provided
4. Energy Management and Controls System
 - a. Content shall be as specified in Section 230923.
5. Warranties and Certifications
 - a. Shall include:
 - 1) Test and balance reports

- 2) Test records of piping, ductwork, etc
- 3) Signed checklist of instruction period
- 4) Copies of specific product warranties
- 5) Copies of certified factory start-up reports
- 6) Valve tag identification schedules
- 7) Copy of manual describing specific maintenance services that will be furnished under this contract.
- 8) Seismic Certification
- 9) Equipment seismic certification

- F. Prepare two (2) printed copies in three ring binders of approved manuals for use during the instruction period.
- G. Following instruction period, turn over both printed copies and electronic files to the Owner's Representative and the Owner.
- H. Manuals may be compiled in multiple volumes if necessary for ease of use.

3.11 PROJECT CLOSEOUT/CERTIFIED FACTORY START-UP

- A. Refer to individual sections of these Specifications for specific requirements of certified factory start-up.
- B. Start-up shall be performed by a certified factory representative. Prior to start-up, certification of factory representative shall be forwarded to the Engineer for review.
- C. Start-up shall be scheduled with the owner to allow witnessing of start-up procedures by maintenance personnel. Operation and maintenance training for equipment requiring certified factory start-up shall be conducted at the time of start-up with the certified factory representative present.
- D. Factory Startup for the Air Handlers & Air Cooled Condensing Unit is provided by CWU.
- E. Certified factory start-up is required for the following equipment:
 1. Chemical Water Treatment
 2. Variable Frequency Drives
 3. Airflow Monitor Stations
 4. Base Mounted End Suction Pumps

3.12 PROJECT CLOSEOUT/OPERATION AND MAINTENANCE TRAINING

- A. General
 1. Two (2) training sessions shall be scheduled. The first shall occur after final inspection and prior to substantial completion. The second shall occur prior to the end of the first year of operation after acceptance. Training sessions shall be scheduled with the owner a minimum of two (2) weeks in advance.

2. Instruct the Owner's representative(s) in operation and maintenance of Division 23 systems utilizing Operation and Maintenance Manual.
3. Individuals present shall include the Division 23 contractors, subcontractors and equipment factory representatives as appropriate. Certified factory representatives shall be present for all equipment requiring certified factory start-up.
4. The contractor's representative performing the operation and maintenance training shall locate in the building each piece of equipment included in the O&M manuals, and shall instruct to the satisfaction of the owner's representative required operation and maintenance procedures as outlined in the O&M manuals.
5. Provide a digital video of the training sessions conducted and furnish copies of the video to the Owner. Digital videos shall be of sufficient quality to allow training of future employees or refresher training of personnel. Use DVD format unless directed otherwise by the owner.
6. Training shall occur after final inspection and prior to acceptance by owner. It shall be scheduled with the owner, and shall occur in one consolidated session for all Division 23 equipment.
 - a. Exceptions:
 - 1) Training for equipment requiring certified factory start-up shall be conducted at the time of start-up.
 - 2) Multiple sessions shall be scheduled as required to maintain a maximum allowable duration of any single session of four (4) hours.
 - 3) When separate training sessions are warranted to achieve proper training on all equipment and systems, as determined by the owner's representative, multiple sessions shall be scheduled as required.
 - 4) EMCS system training shall occur independently, and shall be in accordance with the requirements of Section 230923.
 - 5) Training session shall include all equipment included in the table at the end of this section. A table similar to this one shall be used to verify owner training has been completed on all equipment, and shall be included in the Operation and Maintenance Manual.
7. A second training session shall occur prior to the end of the first year of operation after acceptance. Prior to this session, the owner shall submit a list of items to be covered. This session shall include all parts of the first training session necessary to meet the satisfaction of the owner, up to and including full training of all equipment and systems.

3.13 PROJECT CLOSEOUT/SPARE PARTS/MAINTENANCE MATERIALS

- A. A list of spare parts to be provided under this contract has been included at the end of this section. Refer to individual specification sections for specific requirements of spare parts to be furnished under this contract.
- B. Turn spare parts and materials over to Owner.
- C. Provide summarized list of spare parts that have been furnished. List shall include verification by owner's representative that parts have been furnished. Incorporate into O&M Manual. Spare parts list shall be similar to that provided at the end of this section.

3.14 PROJECT CLOSEOUT/96-HOUR RUN TEST

- A. The 96-hour test run shall be made when all field equipment is installed and the system is calibrated and running, test and balance is complete, and when all other building systems (including drywall, windows, doors, etc.) are complete. This period is intended to demonstrate the operation of the complete building.
- B. The 96-hour run test shall include performance of all associated software and hardware operations called for in these specifications. The test shall be for a duration of 96 continuous hours with no Contractor maintenance required. The pre-balance conference shall not be scheduled until this test has been completed satisfactorily (i.e. run without errors or alarms for a continuous 96-hour period). Notify owner's representative prior to beginning the 96-hour run test.

3.15 PROJECT CLOSEOUT/PRE-BALANCE REQUIREMENTS (REFER TO SECTION 230593).

- A. Provide Balance Agency with four (4) weeks written notice prior to start of Balance.
- B. Pre-Balance Conference:
 - 1. Prior to commencing Balancing, assemble the following parties at the project site for a pre-balance conference.
 - a. General Contractor
 - b. Plumbing Foreman
 - c. Sheet Metal Foreman
 - d. Control Technician
 - e. Electrician
 - f. Balance Agency
 - g. Owner's Representative
 - 2. Submit a pre-balance checklist similar to the table at the end of this section to the Balancing Agency and the Owner's Representative at the time of the pre-balance conference indicating that the system is ready for balance. The table at the end of this section shall be referenced for the minimum amount of information to be included in this checklist.
 - 3. Should it be determined at the Pre-Balance Conference that the systems are not ready for balance, the balance shall be re-scheduled and the Owner's Representative shall be reimbursed for their travel cost and time at their normal hourly rates.
 - 4. The Contractor shall make adjustments and changes in fan sheaves, belts, dampers and valves as required to achieve correct balance as recommended by the Balancing Agency at no additional cost to the Owner.
- C. The Contractor shall furnish the Balance Agency with a complete set of Contract Documents including drawings, specifications, shop drawings and change orders pertinent to testing and balancing.
- D. The Contractor shall perform the following tasks and provide the following items to the Balance Agency:

1. The Contractor shall put heating, ventilating, and cooling systems and equipment into full operation and continue their operation during each working day of testing and balancing for the Balancing Agency.
 2. The Contractor shall make the sheet metal foreman and control contractor available upon request to aid in troubleshooting for the Balancing Agency.
 3. The Contractor shall furnish all scaffolding, ladders, and access tools for the Balancing Agency.
 4. Make adjustments and changes in fan sheaves, belts and dampers as required to achieve correct balance as recommended by the Balance Agency at no additional cost to the Owner.
 5. Arrange access to all dampers, valves, balancing devices and operating equipment during the time that testing and balancing is to be performed.
- E. The Control Contractor shall instruct the Balance Agency in the proper procedure for setting the controls, and provide a lap computer for accessing the control system. Upon completion of Balance, the laptop shall become the property of the Control Contractor.
- F. The Control Contractor shall allow time for a control technician to assist the Balancing Agency.

3.16 PROJECT CLOSEOUT/WARRANTIES

- A. Provide specific equipment/material warranties that extend beyond 1 year project warranty period.
1. Refer to individual specifications sections for required extended warranties.
 2. Incorporate extended warranties into O&M Manual in warranties section.

3.17 PROJECT CLOSEOUT/FINAL CLEANING

- A. Clean up all equipment, materials, cartons and other debris that is a direct result of the installation of equipment under this contract.
- B. Clean exposed piping, ductwork and equipment. Repair damaged finishes and leave everything in working order.

3.18 PROJECT CLOSEOUT/RECORD DRAWINGS

- A. Record differences between mechanical work as installed and as shown in Contract Documents on a set of prints of mechanical drawings to be furnished by Owner's Representative. Return these prints to Owner's Representative at completion of Project. Notations made on drawings shall be neat and legible. These drawings shall not be used for any other purposes.
1. Coordination drawings and fabrication drawings may not be utilized as record drawings unless
 - a. Content from original drawings set such as notes and keynotes are transferred over to the coordination and fabrication drawings

- b. Drawings shall not be multidiscipline (ie plumbing and HVAC on same sheet) unless prepared that way in the construction documents
 - c. Drawings clearly identify deviations/modifications to the construction documents
- B. Refer to individual specification sections for additional requirements.

3.19 PROJECT CLOSEOUT/PUNCH LIST PROCEDURES

- A. The Contractor shall notify the Owner's Representative in writing when the project is ready for punch lists. The following items must be complete before punch list will be performed, and must be provided with written verification:
- 1. Systems are complete and functional, including temperature controls.
 - 2. Testing and balancing is complete, and test and balance reports have been submitted for review.
 - 3. Operation and Maintenance Manuals are complete and have been submitted for review.
- B. After punch lists are complete, written notice must be forwarded to the Owner's Representative requesting final checkout. Any additional trips beyond the final checkout required due to incomplete items on previous punch lists will be billed to the Contractor at normal rate plus travel expenses.
- C. At the time of initial and final observation, the project foreman shall accompany the observation party and shall remove access panels and perform other duties, as required, to allow complete observation of the entire Division 23 system.

3.20 PROJECT CLOSEOUT/MAINTENANCE SERVICES

- A. Provide a separate manual describing specific maintenance services to be provided under this contract as required under specific specification sections.

3.21 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

PART 4 - TABLES

4.1 COST BREAKDOWN

- A. Provide cost breakdowns for the categories that follow. Each category shall identify separate costs for material and labor/installation.
- B. Category:
 - 1. Mobilization
 - 2. Supervision
 - 3. Chemical Water Treatment
 - 4. Refrigerant Piping and Accessories
 - 5. HVAC Piping equipment: water pumps, air separators, expansion tanks etc.
 - 6. HVAC Piping
 - 7. HVAC Piping Insulation
 - 8. Ductwork Fabrication
 - 9. Ductwork Installation
 - 10. Duct External Insulation
 - 11. EMCS Programming and Submittals
 - 12. EMCS Equipment
 - 13. Air and Water Balance
 - 14. Commissioning Assistance

4.2 SPARE PARTS LIST

- A. Section 232123, Pumps
 - 1. One (1) set of mechanical seals for each pump
- B. Section 234000, HVAC Fans
 - 1. Two (2) spare direct drive fans per supply and return array. Total of (4) spare fans.
- C. Section 234000, Air Cleaning Devices
 - 1. One (1) spare set of filters for each filter bank
 - 2. One (1) set of activated carbon filters as outlined in 234000.

4.3 PRE-BALANCE CHECKLIST

Pre-Balance Checklist	
Item	Complete
General Contractor	
96-hour run test complete	

Pre-Balance Checklist	
Item	Complete
Piping Contractor:	
All valves, flow meters, temperature/pressure taps installed correctly, functional and accessible	
Strainers and piping, clean, flushed, and free of debris	
Construction strainer baskets replaced with permanent baskets	
System filled to proper level and pressure reducing valve set	
Automatic and manual air vents properly installed and functional	
All air purged from system	
Water in expansion tanks at proper level	
All coils piped correctly and accessible	
Correct pump rotation	
Pumps properly aligned, grouted, and anchored	
Vibration isolators properly installed and adjusted	
Service and balance valves are open	
Sheet Metal Contractor	
Ductwork is intact and properly sealed	
Ductwork leak tested and repaired as required	
Access doors installed and properly secured	
Ductwork end caps installed	
Ductwork installed according to drawings and specifications	
Ductwork is free of debris	
Filters are clean and correctly installed	
Filter frames correctly installed and sealed	
Coils clean, properly installed and sealed	
Drive components installed	
Automatic control dampers installed and functional	
Fan rotation correct	
Fan housing installed and sealed	
All flex connections and vibration isolators are installed correctly	
Fan wheel aligned with adequate clearance	
Fan bearings lubricated	
Controls Contractor	
Controls complete and functional	
Thermostats and sensors calibrated	
Program correct and functional	
Electrical Contractor	
Motors wired and energized	
Proper starter and overload protection installed	
Correct fuses installed	
Motor secured to frame	
Motor bearings lubricated	
Fire alarms and duct smoke detectors are fully operational	

Pre-Balance Checklist	
Item	Complete
General Contractor Sign-Off: _____	Date: _____
Piping Contractor Sign-Off: _____	Date: _____
Sheet Metal Contractor Sign-Off: _____	Date: _____
Controls Contractor Sign-Off: _____	Date: _____
Electrical Contractor Sign-Off: _____	Date: _____

END OF SECTION 23 0500

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Common requirements for electric motors furnished on equipment specified in other Sections, including single phase and three phase electric motors.

1.2 RELATED SECTIONS

- A. All mechanical sections with motor driven equipment
- B. Section 230500 – Common Work Results for HVAC
- C. Section 230923 – Direct-Digital Control for HVAC
- D. Section 230995 – Variable Frequency Drives

1.3 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings
- B. NEMA MG 1 - Motors and Generators
- C. NFPA 70 - National Electrical Code

1.4 REGULATORY REQUIREMENTS

- A. Conform to UL Component Recognition for appropriate sizes
- B. Conform to NFPA 70 and applicable State energy code

1.5 DELIVERY, STORAGE, AND HANDLING (REFER TO SECTION 230500)

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

PART 2 - PRODUCTS

2.1 MANUFACTURERS (REFER TO SECTION 230500):

- A. Century
- B. Baldor
- C. Marathon
- D. General Electric
- E. Westinghouse

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Motors less than 250 Watts, for intermittent service: Equipment manufacturer's standard and need not conform to these specifications.
- B. Motors which are to be controlled from a variable frequency drive shall be designed and constructed for full compatibility with the drive.
- C. Electrical Service:
 - 1. Unless indicated otherwise on equipment schedules, motors shall be supplied as with the following electrical characteristics:
 - a. Motors $\frac{1}{2}$ horsepower and smaller: 115 single phase, 60 Hz
 - b. Motors larger than $\frac{1}{2}$ horsepower shall be three phase and shall be rated as specified and scheduled
- D. Design for continuous operation in 104 °F environment.
- E. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- F. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency.
- G. Efficiency
 - 1. All motors shall meet or exceed minimum efficiency requirements of the State Energy Code.
 - 2. ECM motors shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 C.F.R 431.
 - 3. Design A and B squirrel-cage T-frame induction permanently wired three phase motors of 1 HP or more shall be "premium efficient" and shall have a nominal full-load motor

efficiency no less than the corresponding values for energy efficient motors provided in NEMA standard MG-1. Exceptions:

- a. Motors installed in space conditioning equipment that have certified SEER /EER levels. This exception is to be utilized for electrically operated unitary air conditioners and condensing units as identified in the State Energy Code.

H. Inverter Duty Motors (For Use with Variable Frequency Drives):

1. Provide where scheduled on the drawings
2. Motors shall meet NEMA MG-1 Part 31 requirements. Nameplates shall state motors are "inverter duty". Motors shall be suitable for variable torque and have a 10:1 speed ratio.
3. Critical vibration frequencies are not within operating range of controller output.
4. Temperature rise: Class B at rated full load.
5. Insulation: Minimum Class F
6. Provide with shaft grounding rings. Aegis or approved equal.

I. Wiring Terminations:

1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
2. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

2.3 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque
- B. Starting Current: Up to six times full load current
- C. Multiple Speed: Through tapped windings
- D. Open Drip-proof and Enclosed Air Over Enclosure: Class F insulation, rated for 311 °F maximum temperature, NEMA Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.

2.4 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque
- B. Starting Current: Less than five times full load current
- C. Pull-up Torque: Up to 350 % of full load torque
- D. Breakdown Torque: Approximately 250 % of full load torque

- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof and Enclosed Motor Enclosures: Class F insulation, rated for 311 °F maximum temperature, NEMA Service Factor, prelubricated sleeve or ball bearings.

2.5 ELECTRICALLY COMMUTATED MOTORS (ECM) SINGLE AND THREE PHASE POWER

- A. ECM motors shall be variable-speed, DC, brushless motors specifically designed for use with single phase, 277 volt (or 120 volt), 60 hertz electrical input. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps.
- B. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the blower. Motor shall maintain a minimum of 70% efficiency over its entire operating range. Provide manual (or optional remote) fan speed output control for field adjustment of the flow setpoint. Inductors shall be provided to minimize harmonic distortion and line noise. Provide isolation between motor assembly and unit casing to eliminate any vibration from the fan/motor to the equipment casing. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy.
- C. The equipment manufacturer shall provide a factory installed PWM controller for either manual or DDC controlled flow adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 Vdc signal from the DDC controller (provided by the controls contractor) to control the flow. When the manual PWM controller is used, the factory shall preset the flow as shown on the schedule. Control type shall be as indicated on the drawings.

2.6 THREE PHASE POWER - SQUIRREL-CAGE MOTORS

- A. Starting Torque: Between 1 and 1½ times full load torque
- B. Starting Current: Six times full load current
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics
- D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors
- E. Insulation System: NEMA Class F or better
- F. NEMA Service Factor

- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- I. Sound Power Levels: To NEMA MG 1
- J. Weatherproof Epoxy (where indicated) Motors: Epoxy coat windings with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.

2.7 ENCLOSED MOTOR CONTROLLERS (MOTOR STARTERS)

- A. Enclosed Motor Controllers (starters) and switches are not under Mechanical unless specifically specified with a particular mechanical equipment item.
 - 1. Exception: Variable frequency drives furnished under Section 230923.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- B. Check line voltage and phase and ensure agreement with nameplate.
- C. Motor starters and disconnects are not installed or furnished under Mechanical unless specified or scheduled to be factory furnished and mounted with a particular mechanical equipment item. Starters which are furnished with a particular mechanical equipment item but are shipped loose are not installed or wired under Mechanical.
- D. Variable frequency drives are furnished by Section 230923 in accordance with Section 230995, with installation and power wiring by Division 26. Install shaft grounding rings on all VFD controlled motors.
 - 1. Exception: Drives shall be factory furnished, mounted and wired by associated equipment manufacturer when specified.
- E. Application
 - 1. Open drip-proof enclosures (ODP) except where specifically noted otherwise.
 - 2. Totally enclosed fan cooled (TEFC) where exposed to weather or moisture.
 - 3. Unless scheduled otherwise on the drawings, provide the following motor types:

- a. Fan motors between 1/12 hp and 1 HP shall be provided with ECM motors. Provide with controls for balancing or for remote control operations as indicated in the control drawings. Exceptions:
 - 1) Belt driven fans may use sheave adjustments for airflow balancing if not specified/scheduled to have variable frequency drives.
 - 2) Motors in the airstream of heating terminal units that only operate when providing heat to the space served.
 - 3) Motors installed in space conditioning equipment that have certified SEER /EER levels as specified in the State Energy Code.
 - 4) Motors for smoke control.
 - 5) Motors for clothes dryer booster fans
- b. Single phase fans and blowers (shaft mounted) that do not fall under the ECM requirements above shall be permanent split capacitor type.
- c. Single phase fans (non-shaft mounted), pumps, and air compressors that do not fall under ECM requirements above shall be capacitor start type.
- d. Three phase motors that do not fall under ECM requirements shall be squirrel-cage type

F. NEMA Open Motor Service Factor Schedule

HP	1800 RPM Motor
1/6 to 1/3	1.35
½ to ¾	1.25
1 to 150	1.15

END OF SECTION 23 0513

SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Flashing
- B. Sleeves

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230548 – Vibration Isolation
- C. Section 230700 – HVAC Insulation
- D. Section 232113 – Hydronic Piping
- E. Section 232300 – Refrigerant Piping
- F. Section 233100 – HVAC Ducts and Casings

1.3 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Product Data: Provide manufacturers catalog data
- B. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

PART 2 - PRODUCTS

2.1 FLASHING

- A. Roof Flashing
 - 1. Flashing materials shall be coordinated and approved by the roof manufacturer and not alter the roof warranty.
 - 2. Product may include:
 - a. Oatey Master Flash: EPDM and compounded for maximum resistance for weathering due to ozone or UV light. Pliable and accommodates vibration, pipe movement caused by expansion and contraction and snow-load movement.

Continuous temperature resistance of 212 degrees F. Suitable for any roof pitch
Not for use on hot mopped or built-up roofs.

- b. Oatey All Flash No-Calk Roof Flashings: Thermoplastic, aluminum (0.032"), or galvanized base flashings (24 gauge).
- c. FlashCo L-Series lead flashing for round roof penetrations with counterflashing for vent pipes.
- d. Accessories:
 - 1) Stainless steel hose clamp
 - 2) Caulking for non-vent applications
 - 3) Bonnets or collars with material matching flashing

B. Other Flashing

- 1. Flexible Flashing: 47 mil galvanized steel shell and base, rigid insulation, mitered 3 inch cant, wood nailer, with variable step to match roof insulation and gravel
- 2. Metal Flashing: 26 gauge galvanized steel
- 3. Metal Counterflashing: 22 gauge thick galvanized steel

C. Caps: Steel; 22 gauge minimum; 16 gauge at fire resistant elements

2.2 SLEEVES

- A. Sleeves for Pipes through Non-fire Rated Floors: 18 gauge thick galvanized steel.
- B. Sleeves for Pipes through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18 gauge thick galvanized steel.
- C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed, refer to Division 7.
- D. Sleeves for Round Ductwork: Galvanized steel.
- E. Sleeves for Rectangular Ductwork: Galvanized steel.
- F. Sleeves for below grade piping passing under footings: Class 52; ductile iron.
- G. Sleeves for below grade piping passing through exterior walls - Mechanical Rubber Pipe Seals.
- H. Stuffing Insulation: Glass fiber type; non-combustible; 3 lb. density.
- I. Fire Safeing Sealant: Intumescent material capable of expanding up to 8 to 10 times when exposed to temperatures beginning at 250 °F. It shall have ICBO, BOCA I approved ratings to 3 hours per ASTM E814 (UL 1479). 3M Fire Barrier Caulk, Putty, strip and sheet forms. Refer to Division 7.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install in accordance with manufacturer's instructions.

3.2 FLASHING

- A. Flashing shall be coordinated with roofing system requirements and shall suit style and type of roofing used. All roof flashing shall be approved by the roof material contractor and be compatible with the roofing system warranty. Install in accordance with the roofing manufacturer's recommendations.
- B. All pipes passing through the roof shall be flashed at the roof and shall extend at least 10 inches in all directions from the pipe and run vertically up the pipe not less than 12 inches above the roof. Each pipe shall be counterflashed and made tight with lead counterflashing, extending down inside the pipe 1½ inches and lapping over outside flashing 3 inches or with a Zurn Z-196 vent fitting.
- C. Counterflashing for all roof mounted mechanical equipment shall be the responsibility of this Contractor and shall be completely coordinated with the Contractor providing curbs and roofing.
- D. Provide curbs for mechanical roof installations 12 inches minimum high above roofing surface unless otherwise indicated. Flash and counterflash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints.
- E. Adjust storm collars tight to pipe with bolts; calk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.3 SLEEVES

- A. Provide sleeves for above grade duct and piping penetrations of walls, roofs and floors.
- B. Duct sleeves shall be 18 gauge galvanized steel. See drawings and details for pipe sleeves.
- C. Set sleeves in position in formwork. Provide reinforcing around sleeves.
- D. Size sleeves large enough to allow for movement due to expansion and contraction but not less than (2) pipe sizes larger than piping run. Provide for continuous insulation wrapping, where required.
- E. Where piping or ductwork penetrates a roof, floor or wall, close off space between pipe or duct and sleeve with 3 lb. Fiberglass insulation and elastomeric Sealant (air tight). This applies to all roofs, walls or floors regardless of fire rating. Note: 3 lb. insulation not required at roof penetrations. Use fire safeing sealant at penetrations of fire rated floors and walls.

1. See Section 230548 for supplemental requirements for penetration isolation.
- F. Provide chrome plated cast brass, one piece escutcheons at all pipe penetrations of finished surfaces (walls, ceilings, floors). Provide security set screw.
- G. Refer to details on drawings for duct penetrations of secure walls and piping and duct penetrations of seismic joints.
- H. Furnish and install waterproof sleeves on all piping penetrations through the floor slabs in mechanical room floor or any area where pipes pass through slabs where water spillage could cause damage to ceilings below. Top of sleeve shall extend 2 inches above floor.
- I. Sleeves are not required for core drilled holes.

END OF SECTION 23 0517

SECTION 23 0519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pressure Gauges (Hydronic Service)
- B. Pressure Gauge Tappings
- C. Stem Type Thermometers and Supports
- D. Test Plugs and Kits

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230923 – Direct-Digital Control for HVAC
- C. Section 232113 – Hydronic Piping
- D. Section 232300 – Refrigerant Piping

1.3 REFERENCES

- A. Pressure Gauges
 - 1. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. General
 - 1. Provide manufacturers data which indicates use, construction, operating range, total range, accuracy, and dimensions.
 - 2. Provide a Gauge Application Table indicating each different use of gauges and the gauge range to be utilized, including minimum and maximum measurement values.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 OPERATION AND MAINTENANCE MATERIALS (REFER TO SECTION 230500)

- A. General: Include instructions for calibrating instruments.

1.6 PROJECT RECORD DOCUMENTS

- A. Record actual locations of components and instrumentation.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Do not install instruments when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES (HYDRONIC SERVICE)

- A. Manufacturers (Refer to Section 230500):
 - 1. Trerice
 - 2. Weiss
 - 3. Weksler
 - 4. Tel Tru
 - 5. Miljoco
- B. Basis of Design: Trerice Series 600CB
- C. Construction: ASME B40.1; 4½ inch dial; cast aluminum case; brass tube and socket; brass movement; painted aluminum dial with black graduations on white background; suitable for outdoor use; psi scale as appropriate for intended use; full scale accuracy of plus or minus 1 %.
- D. Provide with ¼" NPT brass ball valve and brass pressure snubbers with ¼" NPT connection.

2.2 PRESSURE GAUGE TAPPINGS

- A. ¼ inch NPT brass ball valve rated for 250 psig; brass pressure snubber with ¼ inch NPT connections.
- B. For steam systems, provide ¼ inch cast iron syphon, NPT angle or straight pattern.

2.3 STEM TYPE THERMOMETERS AND SUPPORTS

- A. Manufacturers (Refer to Section 230500):
 - 1. Duro

2. Trerice
3. Weiss
4. Weksler
5. Tel Tru
6. Miljoco

- B. Basis of Design: Trerice Series Cx9
- C. Construction: Twelve (12) inch high, adjustable angle; blue colored organic spirit; lens front tube; UV protected clear acrylic window up to 300 °F and double strength above 300 °F; ¾ inch long NPT brass stem with 2½ inch insertion length; cast aluminum case with enamel or epoxy finish; cast aluminum adjustable joint with positive locking device; scale to suit application; well to suit service; full scale accuracy within 2 %; Fahrenheit scale as appropriate for intended use.
- D. Supports: Brass separable sockets for thermometer stems with or without extensions as required.

2.4 TEST PLUGS

- A. Test Plug:
1. Manufacturers (Refer to Section 230500):
 - a. Flow Design
 - b. MG Piping Products
 - c. Pete's Plugs
 - d. Sisco
 - e. Trerice
 2. Construction: ¼ inch NPT or ½ inch NPT brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 °F; nordel core for temperatures up to 350 °F; viton core for temperatures up to 400 °F; brass extension for insulated pipe.

2.5 HYDRONIC FLOW METERS

- A. Water flow and energy meters for use in Hydronic Systems are furnished in Section 230923.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install in complete conformance with the manufacturer's instructions.
- B. Coil and conceal excess capillary on remote element instruments.

- C. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- D. Install gauges and thermometers in locations where they are easily read from normal operating level without crawling or climbing. Install vertical to 45 degrees off vertical.
- E. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

3.2 PRESSURE GAUGES

- A. Provide pressure gauges where indicated on plans.
- B. Install pressure gauges with snubbers. Provide ball valve to isolate each gauge. Install syphon on gauges in steam systems. Extend nipples and syphons to allow clearances from insulation.
- C. Install one pressure gauge per pump, (whether indicated on the drawings or not), with taps and isolation valves to isolate total, suction, and discharge pressures. Points of connection shall be before strainers and on suction and discharge of pump; pipe to gauge.

3.3 PRESSURE GAUGE TAPPINGS/TEST PLUGS

- A. Install gauge taps/test plugs in piping; refer to related piping specifications sections.
- B. At minimum, provide gauge taps/test plugs for the purposes of calibration of gauges and thermometers installed in this section and calibration of sensors installed for the Energy Management and Direct Digital Control System in Section 230923.
- C. Where gauges and sensors are located at the same hydraulic and thermal point in the piping system (i.e. a pressure gauge, temperature gauge and Section 230923 located together) a single test plug may be provided.
- D. Provide gauge taps/test plugs as follows:
 - 1. Adjacent to pressure gauges
 - 2. Adjacent to thermometers
 - 3. Adjacent to pressure and temperature sensors provided in Section 230923
 - 4. Inlet and outlet of coil or equipment where pressure and temperature gauges are not furnished.
 - 5. Where indicated on drawings.
 - 6. Within 12" of DP sensors.

3.4 STEM TYPE THERMOMETERS AND SUPPORTS

- A. Provide thermometers where indicated on plans. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2½ inches for installation of

thermometer sockets 24 inches on each side of the thermometer. Ensure sockets allow clearance from insulation.

- B. Install where temperature is visible from standing person height.

3.5 TEST PLUGS

- A. Provide temperature and pressure test plugs where indicated on the plans.

3.6 METERS

- A. Install in accordance with the manufacturer's written requirements.

3.7 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 0519

SECTION 23 0523 - GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Access Doors
- B. General Valves
- C. Spring loaded check valves

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230553 – Identification for HVAC Piping and Equipment
- C. Section 230700 – HVAC Insulation
- D. Section 232113 – Hydronic Piping

1.3 GENERAL

- A. All materials shall be compatible with ethylene and propylene glycol.
- B. All valves shall be of the same manufacturer.

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Product Data: Include data on valves and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.

1.6 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Record actual locations of valves and piping.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 230500.
- B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- C. Provide temporary protective coating on iron or steel valves.
- D. Provide temporary end caps and closures. Maintain in place until installation.

PART 2 - PRODUCTS

2.1 GENERAL VALVES

- A. Manufacturers (Refer to Section 230500):

- 1. Bray
- 2. Crane
- 3. Grinnell
- 4. Hammond
- 5. Jenkins
- 6. Milwaukee
- 7. Nibco
- 8. Powell
- 9. Stockham
- 10. Walworth
- 11. Watts
- 12. Apollo

- B. Ball Valves:

- 1. Up to and including 3 inch: Bronze, two piece body, chrome plated brass ball with standard port, teflon seat, and stuffing box ring, lever handle, solder or threaded ends with union, 600 psi WG. Provide with memory stops when used as a balancing cock.

- a. Basis of Design: Milwaukee BA-100S (threaded), Milwaukee BA-150S, (solder)

- C. Butterfly Valves:

- 1. 2 inch: Bronze body; threaded or solder ends; Viton seat; stainless steel disk and stem; lever handle operator; memory stops when used as a balancing cock; 175 psi SWP

- a. Basis of Design: Milwaukee, Butterball BB2-100, threaded. Milwaukee, Butterball BB2-350, solder

2. 2½ to 5 inch: Cast or ductile iron body; wafer or lug type; extended neck; threaded ends; resilient replaceable EPDM seat rated for -20 to 275 °F; aluminum bronze disc; stainless steel stem; infinite position lever (gear operator if chain wheels required) handle operator with memory stop; 200 psi SWP
 - a. Basis of Design: Milwaukee MW223E (wafer). Milwaukee ML223E (lug)
3. 6 to 12 inch: Cast or ductile iron body; wafer or lug type; extended neck; resilient replaceable EPDM seat rated for -20 to 275 °F; aluminum bronze disc; stainless steel stem; gear operator with memory stop 200 psi SWP
 - a. Basis of Design: Milwaukee MW323E (wafer). Milwaukee ML323E (lug)
4. Provide chain wheel operators for valves mounted over 8 feet above the floor in mechanical rooms or valves more than 3 feet above the ceiling.

2.2 SPRING LOADED (SILENT) CHECK VALVES

- A. 2 inches and smaller: Bronze body; bronze trim; vertical lift; teflon seat; threaded or soldered end; MSS class 125; 125 psi SWP. Stainless steel stem.
 1. Basis of Design: Milwaukee 548-T (threaded ends). Milwaukee 1548-T (soldered ends)
- B. 2½ to 10 inches: Iron body; stainless steel trim; split plate; hinged with stainless steel spring; renewable bronze seat and disc; wafer style; ANSI class 125. Accessories: Flanges, bolts, nuts and gaskets
 1. Basis of Design: Milwaukee 1400 Series

PART 3 - EXECUTION

3.1 PREPARATION

- A. Remove scale and dirt on inside and outside before assembly.

3.2 INSTALLATION – GENERAL

- A. Provide valves as indicated on the drawings.
- B. Valves shall be line size unless indicated otherwise.
- C. Valves in mechanical spaces at a height greater than 8 feet shall be provided with gear operators and chain.
- D. Install in accordance with manufacturer's instructions and as indicated on the drawings.

- E. Provide access doors where valves and fittings are not exposed unless indicated to be provided under other divisions. Access doors shall comply with Division 8.
- F. Install valves with stems upright (preferred) or horizontal, not inverted.
 - 1. Where space allows, install butterfly valves in the horizontal position or rotated 45 degrees to prevent premature failure of the liner and accumulation of debris.

3.3 INSTALLATION – VALVES

- A. Use ball or butterfly valves for shut-off and to isolate equipment, of systems, or vertical risers.
- B. Use butterfly valves for throttling, bypass, or manual flow control services.
- C. Provide spring loaded (silent) check valves where indicated on drawings and where two or more pumps are installed in parallel.
- D. Use lug end butterfly valves to isolate equipment.
- E. Use ¾ inch ball valves with cap for drains at main shut-off valves, low points of piping, bases of vertical risers, and at equipment.

3.4 EQUIPMENT MANUFACTURER’S AND CONTRACTOR’S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 0523

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND FITTINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Equipment Curbs
- B. Inserts
- C. Pipe Hangers and Supports
- D. Pipe Shields and Saddles
- E. Resilient Clamps
- F. Equipment Supports

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230548 – Vibration Isolation
- C. Section 230549 – Seismic Controls for Mechanical
- D. Section 230700 – HVAC Insulation
- E. Section 232113 – Hydronic Piping
- F. Section 232300 – Refrigerant Piping
- G. Section 233100 – HVAC Ducts and Casing

1.3 REFERENCES

- A. General
 - 1. ASME B31.5 - Refrigeration Piping
 - 2. ASME B31.9 - Building Services Piping
- B. Pipe Hangers and Supports
 - 1. ASTM F708 - Design and Installation of Rigid Pipe Hangers
 - 2. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer
 - 3. MSS SP69 - Pipe Hangers and Supports - Selection and Application

4. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Product Data: Provide manufacturers catalog data including load capacity.
- B. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.5 REGULATORY REQUIREMENTS

- A. Pipe Hangers and Supports
 1. Hanger and support systems shall conform to MSS SP58, MSS SP69, MSS SP89

PART 2 - PRODUCTS

2.1 EQUIPMENT CURBS

- A. Equipment curbs indicated to be under Mechanical, on mechanical equipment schedules, and specified herein shall be factory fabricated and shall be of the same manufacturer as the supported equipment to ensure compatibility and size coordination. Reference associated equipment specifications and schedules for equipment curb requirements.

2.2 INSERTS

- A. Construction: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment; top slot for reinforcing rods; lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.3 PIPE HANGERS AND SUPPORTS

- A. Manufacturers (Refer to Section 230500):
 1. Grinnell/Anvil
 2. ERICO/Michigan Hanger
 3. Crane
 4. Fee and Mason
- B. Hydronic Piping
 1. Conform to MSS SP58, MSS SP69, and MSS SP89.
 2. Hangers for Pipe Sizes ½ to 2 inches: Carbon steel, adjustable swivel, split ring.
 3. Hangers for Cold Pipe Sizes 2 inches and over: Carbon steel, adjustable, clevis.

4. Hangers for Hot Pipe Sizes 2½ to 6 inches: Cast iron roll; carbon steel yoke, roll rod and hex nuts, clevis.
5. Hangers for Hot Pipe Sizes 6 inches and over: Adjustable steel yoke, cast iron roll, double hanger, clevis.
6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 inches and over: Steel channels with welded spacers and hanger rods, cast iron roll.
8. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
9. Wall Support for Pipe Sizes 4 inches and over: Welded steel bracket and wrought steel clamp.
10. Wall Support for Hot Pipe Sizes 6 inches and over. Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
11. Vertical Support: Steel riser clamp.
12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
13. Floor Support for Hot Pipes Sizes to 4 inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
14. Floor Support for Hot Pipe Sizes 6 inches and over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

C. Refrigerant Piping

1. Conform to MSS SP58, MSS SP69, and MSS SP89.
2. Hangers for Pipe Sizes ½ to 1½ inches: Carbon steel, adjustable swivel, split ring.
3. Hangers for Pipes Sizes 2 inches and over: Carbon steel, adjustable, clevis.
4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
5. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
6. Wall Support for Pipe Sizes 4 inches and over: Welded steel bracket and wrought steel clamp.
7. Vertical Support: Steel riser clamp.
8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

D. Pipe Riser Clamps

1. Steel and Cast Iron Pipe: Extension pipe or riser clamp; carbon steel; black or galvanized finish. Isolator pad shall be used between riser clamp and concrete slab, equal to Holdrite Silencer 278 with 10 gauge bearing plate or approved equal.
 - a. Basis of design: Grinnell Fig 261.
2. Copper Pipe: Copper tubing riser clamp; carbon steel; copper finish. Isolator pad shall be used between riser clamp and concrete slab, equal to Holdrite Silencer 278 with 10 gauge bearing plate or approved equal.
 - a. Basis of design: Grinnell Fig CT-121.

2.4 HANGER RODS

- A. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.5 PIPE SHIELDS AND SADDLES

- A. Manufacturers (Refer to Section 230500):

1. Anvil
2. Fee & Mason
3. M-Co
4. Pipe Shields, Inc
5. Kin-Line

- B. Hot Piping (insulated pipe, 2 ½" and larger):

1. Protection saddle type; size to suit thickness of insulation; curved carbon steel plate; Anvil Fig 160, 161, 162.

- C. Hot Piping (up to 2"):

1. Insulation protection shield type; carbon steel; galvanized finish; Anvil Fig 167.
2. For vertical pipe hanger supports, the shields shall covering the lower 40% of the circumference of the insulation.
3. For pipe installed on trapeze hangers, the shields shall extend to cover the full circumference of the pipe.
4. Shield shall be sized to suite pipe insulation thickness. High density insert furnished in Section 230700 and installed in this section.

- D. Cold Piping:

1. Insulation protection shield type; carbon steel; galvanized finish; Anvil Fig 167.
2. For vertical pipe hanger supports, the shields shall cover the lower 40% of the circumference of the insulation.
3. For pipe installed on trapeze hangers, the shields shall extend to cover the full circumference of the pipe.
4. Shield shall be sized to suite pipe insulation thickness. High density insert furnished in Section 230700 and installed in this section.

2.6 RESILIENT CLAMPS

- A. Refer to Section 230548 for supplemental requirements for penetration isolation. In the event of a conflict, Section 230548 shall take precedence.

- B. Manufacturers (Refer to Section 230500):

1. Hydra-Zorb

- C. Construction: Resilient cushion with clamps and anchoring channel.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Piping shall be installed in such a manner that it is not in contact with metal building components.
- C. Provide neoprene or approved wrap between water piping and metal building components, unistrut or other metal.
 - 1. Exceptions:
 - a. Not required where piping is isolated from hangers with insulation shields.
 - b. Not required where resilient clamps are used.
- D. Concrete housekeeping pads for mechanical equipment are not under Mechanical. Coordinate required location and size with other Divisions and provide equipment shop drawings for proper sizing.
- E. Provide templates, anchor bolts, and accessories for mounting and anchoring to other Divisions as applicable.
- F. Construct supports of steel members. Brace and fasten with flanges bolted to structure.
- G. Provide rigid anchors for pipes after vibration isolation components are installed.
- H. Provide factory pre-fabricated roof curbs (indicated on drawings and equipment schedules to be furnished under Mechanical) in accordance with the manufacturer's recommendations and as indicated on the drawings.

3.2 INSERTS

- A. Provide inserts for placement in concrete formwork.
- B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
- C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
- D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
- E. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab in concealed areas and recessed into and grouted flush with slab in exposed areas.

3.3 PIPE HANGERS AND SUPPORTS

- A. Support horizontal piping in accordance with applicable codes and the table at the end of this section.
- B. Install hangers to provide minimum ½ inch space between finished covering and adjacent work.
- C. Place hangers within 12 inches of each horizontal elbow.
- D. Use hangers with 1½ inch minimum vertical adjustment.
- E. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- F. Support riser piping independently of connected horizontal piping.
- G. Provide copper plated hangers and supports for copper piping.
- H. Design hangers for pipe movement without disengagement of supported pipe.
- I. Prime coat exposed steel hangers and supports. (Refer to Division 9) Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- J. Support vertical piping at every floor penetration with pipe riser clamps.
- K. Support risers independently of connected horizontal piping.
- L. Provide vibration isolation at supports when required by Section 230548.
- M. Provide seismic bracing for pipes where required by Section 230549.

3.4 PIPE SHIELDS AND SADDLES

- A. Provide shields and saddles to protect pipe insulation at hangers. (Furnished and installed under Section 230529.)
- B. Size hangers to accommodate pipe insulation and insulation shields where applicable. See Section 230700.

3.5 PIPE INSULATION INSERTS

- A. Furnished under Section 230700, installed under Section 230529.

3.6 RESILIENT CLAMPS

- A. Use to attach tubing, pipe, or hoses to vibrating machinery or equipment.

- B. Use to isolate piping from contact with other metals, steel partition studs.

3.7 EQUIPMENT SUPPORTS

- A. Provide supports and attachments to structure as required for installation of equipment. Supports shall be for basemounted or suspended applications to suit project conditions or as indicated on drawings.
- B. Supports shall comply with Section 230548 and Section 230549.

PART 4 - TABLES

Pipe Size inches	Max. Horizontal Spacing for Hangers feet		Hanger Rod Dia. inches
	Threaded or Welded Joints	Copper Tube and Piping (soldered, brazed or welded joints)	
	Steel		
½	10	6	3/8
¾	10	6	3/8
1	10	6	3/8
1¼	10	6	3/8
1½	12	6	3/8
2 to 3	12	10	½
4 to 6	12	10	5/8
8 to 12	12	10	7/8
Notes: 1. Vertical piping shall be supported in accordance with tables 313.3 and 313.6 of the Uniform Plumbing Code as amended by Washington state.			

END OF SECTION 23 0529

SECTION 23 0548 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Open Steel Spring Isolators
- B. Restrained Spring Isolators
- C. Spring and Neoprene Hangers
- D. Neoprene Waffle Pads
- E. Inertia Bases
- F. Flexible Duct Connections
- G. Flexible Pipe Connections

1.2 RELATED SECTIONS

- A. Division 03
- B. Section 230500 – Common Work Results for HVAC
- C. Section 230549 – Seismic Controls for Mechanical
- D. Division 23 piping, ductwork and equipment as specified herein.

1.3 REFERENCES

- A. 2019 ASHRAE Handbook—HVAC Applications, Chapter 49 – Noise and Vibration Control

1.4 PERFORMANCE REQUIREMENTS

- A. Provide minimum static deflection of isolators for equipment as indicated in Chapter 49 - Noise and Vibration Control (Table 47) of the 2019 ASHRAE Handbook—HVAC Applications.

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Product Information: Provide material and type of construction. Provide schedule of vibration isolator type with location and load on each.
- B. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.

PART 2 - PRODUCTS

2.1 GENERAL ISOLATORS

- A. Manufacturers (Refer to Section 230500):
1. Amber Booth
 2. Kinetics
 3. Korfund
 4. Mason Industries
 5. Isolators provided by the manufacturer of isolated equipment as an accessory to that equipment are acceptable when indicated in these specifications or on the drawings to be provided with isolation equipment as an accessory to the equipment.
- B. Open Steel Spring Isolators: Adjustable, freestanding, open steel spring mounting with top and base plates designed to allow rigid attachment to the machinery frame and supporting structure, respectively. Used for equipment that does not encounter weight removal or wind loads. Neoprene pad must be located under the baseplate and not between the baseplate and spring. Spring shall provide an additional travel to solid distance equal to 50 % of the rate deflection.
1. Basis of Design: Mason Industries, type SLF.
- C. Restrained Spring Isolators: Adjustable, open spring isolator, similar to Open Steel Spring, with a frame to include vertical resilient stops to prevent spring extension when weight is removed. For equipment whose operating weight may differ from isolated weight, mounts shall be designed with fail-safe feature to protect against wind loads and overturning of mounts in earthquakes. Mounts shall be capable of withstanding lateral accelerations of 1g. Allow ½ inch (13 mm) clearance around vertical restraining bolts, with neoprene grommets and washer to prevent restraining bolts from short circuiting isolation. Limit stops must be out of contact during normal operation. Springs shall provide an additional travel to solid distance equal to 50 % of the rated deflection.
1. Basis of Design: Mason Industries, type SLR
- D. Spring and Neoprene Hanger or Neoprene Hanger: Spring and neoprene hanger consisting of a steel spring in series with a neoprene isolation element or neoprene hanger as scheduled with equipment to be isolated. Where not indicated, spring and neoprene hanger shall be used. Springs shall provide an additional travel to solid equal to 50 % of the rated deflection. Isolator assembly shall be designed to support five times overload without failure and allow up to 15 degrees of hanger rod misalignment. Hangers shall be attached directly to the structure with a single hanger rod making the balance of the connection. Spring housings shall include a neoprene bushing between the housing and the threaded rod to prevent metal-to-metal contact between the spring housing and the threaded rod in case of misalignment.
1. Basis of Design: Mason Industries, type DNHS
- E. Neoprene Waffle Pads: Minimum ¾ inch (20 mm) thick; maximum loading 40 psi (280 kPa). If equipment will be bolted to floor through the waffle pads, neoprene bushings shall be used

with the mounting bolts to prevent the mounting bolt from contacting the mounting flange of the equipment.

1. Basis of Design: Mason "Super W"; Pads and Mason HG Bushings

- F. Structural Steel Base: Structural steel rectangular base with cross members to prevent twisting where longest beam dimension exceeds 6 feet (1.8 m). Use height-saving brackets for side mounting of isolators.

1. Basis of Design: Mason Industries, type WF

- G. Inertia Bases: Concrete filled base sized to support equipment without overhanging structural steel members that form perimeter framing. Concrete shall be in accordance with Section 033000. Cutout in center may be provided with structural member interior section to adjust base weight if necessary. Total mass of base shall not be less than two times the total weight of all equipment mounted on base unless otherwise indicated. Submit calculations for base deflection. Deflection shall be in accordance with 1995 ASHRAE Handbook, Vibration Isolation. Furnish with preset embedded anchor bolts and pipe sleeves for fan and motor slide rail or other equipment attachment. Size base to support suction elbow of end suction pumps and suction and discharge elbow of horizontal split case pumps, unless flexible neoprene elbows are used. Use T-shape where necessary to conserve weight and size.

1. Basis of Design: Mason Industries, type BMK/K Base

2.2 FLEXIBLE DUCT CONNECTIONS

- A. Manufacturers (Refer to Section 230500):

1. Ventfabrics
2. Duro Dyne

- B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.

- C. Connector: Fabric crimped into metal edging strip.

1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 26 ounces/yard² (26 kg/m²). Rated for -20 °F to 200 °F (-29 °C to 93 °C) for standard, non-corrosive, indoor applications.

2.3 FLEXIBLE PIPE CONNECTORS

- A. Flexible Pipe Connectors

1. Braided Hose for Hydronic piping
 - a. Braided flexible stainless steel hose.
 - b. Hose to be rated at a minimum of 250 psi at 250 degrees F.

- c. Hose to be installed horizontally and parallel to equipment shaft.
 - d. Hose to have a minimum length of 18 inches.
 - e. Hose for 2 inch pipe size and smaller to be equipped with male nipple fittings.
 - f. Hose for 2½ inch pipe size and larger to be equipped with fixed steel flanges.
 - g. Hose to be selected for operating pressure with 4:1 minimum safety factor.
 - h. Acceptable Products:
 - 1) Model BSS by Mason
 - 2) Hyspan
 - 3) Twin City Hose
2. Refrigerant piping
- a. Mason ULCPS or approved equal.
 - 1) Stainless steel braided hose with copper female sweat ends, UL approved for refrigerant service for pressures, temperatures and refrigerant type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide in accordance with manufacturer's instructions.
- B. Provide isolation for all motor driven equipment furnished in this project.
- C. Install spring hangers without binding. Threaded rods shall be aligned in the center of the spring housing openings and shall not make contact with the spring housings. Seismic restraints shall not short-circuit the vibration isolation components.
- D. Connect wiring to isolated equipment with flexible hanging loop.
- E. Vibration Isolation Schedules:
 - 1. Flexible duct connectors:
 - a. Provide at connections to all air moving equipment unless noted otherwise on the drawings.
 - b. Ensure metal bands at connectors are parallel with minimum 1" flex between ductwork and the fan while running.
 - 2. Neoprene pad:
 - a. Provide continuous pad between each base mounted rail base and the floor/slab or housekeeping pad for base mounted equipment that is not mounted with external spring isolators.
 - b. Equipment

- 1) Air Handling Units

3. External spring base mounted isolators
 - a. Provide restrained spring isolators for roof mounted DX condensing unit CU-5 that serves AHU-4.
 - b. Measure the static deflection of each spring isolator and verify that each spring provides at least 80% of the specified static deflection under load.

4. Flexible piping connections:
 - a. Provide flexible connectors at all base mounted pumps.
 - b. Provide flexible connectors at all connections to isolated air moving equipment.
 - c. Provide flexible connectors at all pipe connections to condensing unit CU-5.

5. Inertia Base:
 - a. Provide at all base mounted pumps on elevated slabs.

END OF SECTION 23 0548

SECTION 23 0549 - SEISMIC CONTROLS FOR MECHANICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. The work in this section consists of providing engineering and materials necessary for seismic restraints for the mechanical systems and equipment provided in this project in division 23.
- B. Division 23 shall include seismic controls in their respective cost/cope of the project in accordance with the requirements of this section.

1.2 RELATED SECTIONS

- A. Division 23 – All sections where piping, equipment and ductwork are furnished
- B. Section 230548 – Vibration Isolation

1.3 WORK INCLUDED

- A. This section provides minimum acceptance requirements for seismic/wind restraints for all piping, ductwork and equipment.
- B. All engineering and seismic controls provided in Section 23 05 49 shall be provided by one source for single source responsibility and coordination.

1.4 QUALITY ASSURANCE

- A. Unless otherwise directed by the local authority having jurisdiction, the following codes and standards apply:
 - 1. International Building Code 2021
 - 2. American Society of Civil Engineers Standard ASCE 7-16
- B. Manufacturer's Qualifications: Vibration Isolation and Seismic Control Manufacturers Association (VISCMA) "Regular Member" firms as defined by VISCMA, <http://www.viscma.com/>
- C. Restraint products tested for performance by third parties.
- D. The manufacturer provided services in this section shall review all equipment submittals prior to preparation of project specific submittal for this project. The manufacturer shall review equipment bases provided with equipment and if bases are not compliant with this section, provide supplemental bases.

- E. The following guides may be used for supplemental information on typical seismic installation practices provided that all work conforms to the International Building Code and ASCE. Where a conflict exists between the guides and these construction documents, the construction documents will preside.
 - 1. Federal Emergency Management Agency (FEMA) manuals 412, Installing Seismic Restraints for Mechanical Equipment and 414, Installing Seismic Restraints for Ductwork and Pipe.
 - 2. Sheet Metal and Air-conditioning Contractors' National Association's (SMACNA) Seismic Restraint Manual Guidelines for Mechanical Systems, 3rd ed., 2008
 - 3. American Society for Heating, Refrigerating and Air-conditioning Engineers' (ASHRAE) A Practical Guide to Seismic Restraint
 - 4. Manufacturers Standardization Society of the Valve and Fittings Industry MSS SP-127-2001, Bracing for Piping Systems, Seismic – Wind – Dynamic, Design, Selection, Application.

1.5 SEISMIC CRITERIA

- A. This section documents the Seismic criteria that apply to this project.
 - 1. Seismic Supports are required for Division 23.
- B. Design and select restraint devices to meet seismic requirements as defined in the International Building Code, and applicable state and local codes and the following project specific requirements.
 - 1. Seismic Design Category [D].
 - 2. Risk Category: III
 - 3. For other Seismic Criteria, see the structural drawings.
 - 4. Mechanical System Importance Factor for Risk Category III facilities:
 - a. All other Division 22/23 Pipe, Ductwork and Equipment, $I_p=1.0$
- C. Except as specifically exempted in this section, engineered supports are required for all mechanical systems furnished in this project for all importance factors.

1.6 SUBMITTALS

- A. Pre-Installation-Part 1
 - 1. Submit the following for review and acceptance to the Owner's representative.
 - a. Supports
 - 1) Provide submittal drawings for all devices specified herein in division 23 and as indicated and scheduled on the drawings. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be

specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, attachment and anchorage requirements.

- 2) Provide calculations for selection of seismic/wind restraints and their positive attachments, certified by a qualified professional engineer, licensed in the state/province of the project.
- 3) Seismic forces at attachment and attachment methods shall be clearly indicated for review by the project structural engineer.
- 4) Stamped submittal package shall be project and product specific. Generic stamped calculations are not acceptable.

B. Pre-Installation-Part 2

1. After acceptance from the registered design professional, submit design and documentation for Approval by the Authority having jurisdiction in accordance with ASCE 7-16 part 13.2.1.

C. Post Installation

1. Submit seismic restraint product manufacturer inspection certificate in accordance with Part 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS (REFER TO SECTION 23 05 00)

- A. Vibro-Acoustics
- B. Amber Booth
- C. Kinetics
- D. Korfund
- E. Mason Industries
- F. Equipment with integral bases that meet the base requirements specified in this section shall not have additional bases provided.

2.2 VIBRATION ISOLATION

- A. Refer to Sections 23 05 48 for systems and equipment requiring vibration isolation. Seismic restraints shall factor vibration of spring isolation equipment.

2.3 BASE MOUNTED EQUIPMENT

- A. A restraint assembly for floor mounted equipment consisting of welded steel interlocking assemblies welded or bolted securely to the equipment or the equipment bases and to the supporting structure. Restraint assembly surfaces which engage under seismic motion shall be lined with a minimum ¼" thick resilient elastomeric pad to protect equipment. Restraints shall be field adjustable and be positioned for 1/4" clearance as required to prevent interference during normal operation. Restraint assembly shall have minimum rating of 2 times the catalog rating at 1 G as certified by independent laboratory test.
1. Where the manufacturer determines that the equipment is furnished with a base assembly that is sufficiently rigid to allow direct anchoring to the floor and base mounted spring isolators are not required (23 05 48), provide details for direct mounting of the equipment to the floor or curb or roof structure.
 2. Manufacturer (Refer to Section 23 05 00):
 - a. Amber/Booth restraint type ER

2.4 SEISMIC/WIND RESTRAINTS

- A. Seismic Cable Restraints: Vibro-Acoustics Type BulletBrace™ – Preassembled, adjustable seismic sway bracing restraints shall consist of 7x19 galvanized steel aircraft cable sized to resist seismic loads. Cable restraint system shall be completely preassembled to eliminate onsite assembly of restraint components, and shall allow quick and easy adjustment on the length of the cable after the installation to remove excessive sag on the cable. Cable end connections shall use heavy duty steel brackets, thimbles with Bulletlock cable installation mechanism. Type SRK – wire rope restraints shall have wire rope clips. All seismic cable restraint assembly capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.
- B. Rigid Restraints: Vibro-Acoustics Type RRK-V – Seismic rigid sway bracing restraints shall include heavy duty brackets made of high-strength, low alloy steel designed to provide strength to withstand seismic load. To prevent site confusion, brackets shall be of a universal design for both structural and equipment/piping/ductwork attachments. The brackets shall accommodate post-installation of seismic restraints without the requirement of disassembling the hanger rod or any other support component. Rigid restraint brackets shall be color-coded for capacity identification. Rigid restraint capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.
- C. Seismically Rated Beam Clamp: Vibro-Acoustics Type BulletClamp™ BC-50 – Seismically rated beam clamps for attachment of seismic cable restraints and rigid restraints to structural steel without drilling the structure. Beam clamp shall be constructed of a ductile cast frame, case hardened cone point set screw and related hardware. Clamp frame shall be zinc plated with supplemental yellow chromate treatment, and hardware and set screw shall be zinc plated for corrosion protection. Clamp design shall allow installation of the restraint bracket to the clamp and the clamp to structure with a single attachment point. Published seismic beam

clamp capacities at specified angles shall be established through testing. Test reports will be available by the manufacturer upon request.

- D. Hanger Rod Stiffener Clamp: Vibro-Acoustics Type VAC – Structural steel angle attached with a formed steel clamp to threaded rod support. Steel angle to be provided by contractor; VAC clamp to be provided by seismic restraint manufacturer.
- E. Seismic Inline Pump Stands: Vibro-Acoustics Type SIPS – trapezoidal-shaped rigid support stands made of high strength, low alloy steel designed to be bolted to pipe flanges which support vertical inline pumps. Stands shall include neoprene grommet washers for anchor bolts, and shall be designed to provide adequate restraint for connected equipment to resist seismic loads. Type SIPS-NP – Vibration isolation pads shall be furnished under pump stands as a factory supplied package. All SIPS model seismic allowable load capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.
- F. Seismic Pipe Stand: Vibro-Acoustics Type SPS-6 (Fixed Height) and SPSA-4 & SPSA-6 (Adjustable Height) – rigid support pipe stands made of steel round section supports, designed to support the dead load, and provide enough strength to withstand at least 1 g of lateral seismic force. In addition to providing allowance for roof slopes, the adjustable height stands shall be used to accommodate changing pipe sizes and elevations. Seismic allowable load capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.
- G. Seismic Restraint Brackets: Vibro-Acoustics Type SRB – Formed steel brackets for securing floor-mounted equipment complete with pre-drilled holes. Brackets shall be galvanized or powder coated enamel for corrosion protection. Brackets shall be furnished with grommet washers for vibration isolated equipment.
- H. Seismic Snubber: Structural steel angle(s) with surfaces covered with ribbed neoprene pads to cushion contact with snubber. Customized snubber designs may use other structural shapes and configurations as required. Snubbers shall be designed to limit excessive vibration isolated equipment motion due to wind or seismic loads to no more than 1/4" (6 mm) in any direction.
- I. Concrete Anchor Bolts: Post-installed anchors in concrete shall be qualified for seismic/wind restraint application.
 - 1. Mechanical anchor bolts: Concrete screw type, drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. (In accordance with ACI 355.2 and ICC-ES AC193)
 - 2. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. (In accordance with ACI 355.4 and ICC-ES AC308).

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide in accordance with manufacturer's instructions.
- B. Maintain isolation for all motor driven equipment furnished in this project and allow for movement as identified in 23 05 48.
- C. Coordinate size, doweling, and reinforcing of concrete equipment housekeeping pads and piers with seismic restraint device manufacturer to ensure adequate space and prevent edge breakout failures. Pads and piers must be adequately doweled in to structural slab.
- D. Coordinate locations and sizes of structural supports with locations of vibration isolators and seismic/wind restraints (e.g., roof curbs, equipment skids, etc.).
- E. Isolated and restrained equipment, duct and piping located on roofs must be attached to the structure. Intermediate supports between the restraint points that are not attached to the structure must be approved by the restraint manufacturer.

3.2 CLEARANCES

- A. Maintain a minimum of 3" in all directions between any sprinkler drop or sprig and the following items: permanently attached equipment including their structural supports and bracing; and other distribution systems including their structural sports and bracing.

3.3 SEISMIC/WIND RESTRAINTS

- A. General:
 - 1. All equipment, ductwork, and piping shall be restrained to resist seismic/wind forces per the applicable building code(s) as a minimum. Restraint attachments shall be made by bolts, welds or any other positive fastening methods. Friction shall not be considered as positive attachment. All attachments shall be proven capable of accepting the required wind and seismic loads by calculations. Additional requirements specified herein are included specifically for this project.
 - 2. Install seismic and wind restraint devices per the manufacturer's submittals. Any deviation from the manufacturer's instructions shall be reviewed and approved by the manufacturer.
 - 3. Attachment to structure for suspended equipment, pipe and duct: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
 - 4. Wall penetrations may be used as bracing locations provided the wall can provide adequate resistance without significant damage.
 - 5. Coordinate sizes and locations of cast-in-place inserts for post-tensioned slabs with seismic restraint manufacturer.

6. Provide hanger rod stiffeners where indicated or as required to prevent buckling of rods due to reaction caused by seismic forces.
 7. Where rigid restraints are used on equipment, ductwork or piping, support rods for the equipment, ductwork or piping at restraint locations must be supported by anchors rated for seismic use. Post-installed concrete anchors must be in accordance with ACI 355.2.
 8. Ensure housekeeping pads have adequate space to mount equipment and seismic restraint devices and shall also be large enough to ensure adequate edge distance for restraint anchor bolts to avoid housekeeping pad breakout failure.
 9. Attachments for component anchorage shall meet the requirements of ASCE 13.4.
- B. Concrete Anchor Bolts:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre- or post-tensioned tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Install neoprene grommet washers on equipment anchor bolts where clearance between anchor and equipment support hole exceeds 1/8" (3.2 mm).
 4. Mechanical Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 5. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 6. Set anchors to manufacturer's recommended torque, using a torque wrench.
- C. Equipment Restraints:
1. Seismically restrain equipment as indicated on the schedule. Install fasteners, straps and brackets as required to secure the equipment.
 2. As indicated on the schedule, install seismic snubbers on HVAC equipment supported by floor-mounted, non-seismic vibration isolators. Locate snubbers as close as possible to vibration isolators and attach to equipment base and supporting structure as required.
 3. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- D. Piping Systems:
1. Exemptions: Follow exemptions on applicable building codes as specified in section 1.6.
 2. Restraint spacing:
 - a. For ductile piping, space lateral supports a maximum of 40' (12 m) o.c., and longitudinal supports a maximum of 80' (24 m) o.c.

- b. For non-ductile piping (e.g., cast iron, PVC) space lateral supports a maximum of 20' (6 m) o.c., and longitudinal supports a maximum of 40' (12 m) o.c.
 - c. For piping with hazardous material inside (e.g., natural gas, medical gas) space lateral supports a maximum of 20' (6 m) o.c., and longitudinal supports a maximum of 40' (12 m) o.c.
 - d. For pipe risers, restrain the piping at floor penetrations using the same spacing requirements as above.
3. Brace a change of direction longer than 12' (3.7 m).
 4. Longitudinal restraints for single pipe supports shall be attached directly to the pipe, not to the pipe hanger.
 5. For supports with multiple pipes (trapezes), secure pipes to trapeze member with clamps approved for application.
 6. Piping on roller supports shall include a second roller support located on top of the pipe at each restraint location to provide vertical restraint.
 7. Install restraint cables so they do not bend across edges of adjacent equipment or building structure.
 8. Install flexible metal hose loops in piping which crosses building seismic joints, sized for the anticipated amount of movement.
 9. Install flexible piping connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.
 10. Coordinate seismic restraints with thermal expansion compensators, guides and anchor points. Thermal expansion anchor points shall be designed to accommodate seismic forces.
- E. Conduit
1. Provide seismic restraints as specified for piping systems above.

3.4 INSPECTION AND CERTIFICATION

- A. After installation, arrange and pay for the seismic restraint product manufacturer, or representative, to visit the site to verify that the seismic and wind restraint systems are installed properly, and shall submit a certificate so stating.

END OF SECTION 23 0549

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Ceiling Tacks
- B. Nameplates
- C. Tags
- D. Tag Chart

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Division 23 Piping, Valves, Equipment, and Control Sections

1.3 REFERENCES

- A. ASME A13.1 - Scheme for the Identification of Piping Systems

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Submit list of wording, symbols, letter size, and color coding for mechanical identification of all systems and equipment.
- B. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.

1.5 OPERATION AND MAINTENANCE MATERIALS (REFER TO SECTION 230500)

- A. Include valve tag identification schedule.

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved white letters on black background

2.2 PIPE MARKERS

- A. Manufacturers: (Refer to Section 230500):
 - 1. W.H. Brady
 - 2. Seton
 - 3. Marking Services, Inc.
- B. Color and Lettering: Conform to ASME A13.1
 - 1. CWU Banding Colors:

a. Equipment & Ducts	Gray
b. Chilled Water	Match existing in room.
c. Glycol Chilled Water	Orange with black lettering
d. Controls	Yellow
 - 2. All colors and labeling to be confirmed with Owner prior to install.
- C. Plastic Pipe Markers: Factory fabricated; flexible; semi-rigid plastic; preformed to fit around pipe or pipe covering. Larger sizes may have maximum sheet size with spring fastener.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- E. Plastic Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape; minimum 6 inch wide by 4 mil thick; manufactured for direct burial service.

2.3 TAGS

- A. Description: Brass or Aluminum with stamped letters; tag size minimum 1½ inch diameter with smooth edges.
 - 1. Provide ¼" letters for piping system abbreviation and ½" sequenced numbers. Provide 1/8" hole for fastener.

2.4 TAG CHART

- A. Prepare a complete list or schedule of all valves and trap primers separated by system, giving the number of the valve, its function, location and the rooms or area(s) controlled by it.
- B. Mount in aluminum fram chart in mechanical room.
- C. Include copy in Operation and Maintenance Manual.

2.5 PIPE, DUCTWORK, AND EQUIPMENT LABEL CONTENTS

- A. Include identification of piping and ductwork service using same designations or abbreviations as used on the drawings including pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Coordinate compatibility of piping labels with insulation jackets.
 - 3. Piping markers shall have lettering large enough to be read from the floor (unless the pipe is too small to accommodate that size of lettering, in which case the size of the lettering will be the largest feasible for the pipe size).
 - 4. Adhesive arrow bands shall have a background color that is coded in accordance with the previous table. This matches colors used in the rest of the facility. If the stated background is not commercially available, incorporate arrows into the label and provide color coded bands without arrows.
 - 5. For liquid piping systems, indicate on the labels whether they are supply or return pipes.
- B. Color codes shall be as indicated above.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install in accordance with manufacturer's recommendations.
- B. Prior to installation of all pipe labels in the GeoEco Plant, a mock-up of labeling in a non-visible portion of the GEP or within North Academic Complex shall be completed to be reviewed and approved by the architect/engineer. After review and approval by the architect/engineer, proceed with the installation of remaining pipe labels.

3.2 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Provide identifying devices after completion of coverings and painting.

3.3 NAMEPLATES/LABELS

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- B. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished canvas covering, apply paint primer before applying labels.

3.4 TAGS

- A. Install tags using corrosion resistant chain. Number tags consecutively by location.

3.5 SCHEDULE

- A. Identify all scheduled equipment (pumps, heat transfer equipment, humidifiers, etc.) and water treatment devices with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.
- B. Identify control panels and major control components outside panels with plastic nameplates.
- C. Identify valves in main and branch piping with tags. Exception: check valves, valves with factory-fabricated equipment units. The tag shall be stamped with a number matching valve schedule.
- D. Identify piping, including overflow from automatic air vents and relief valves, direct digital control conduit, and ductwork, concealed or exposed, with plastic pipe markers or plastic tape pipe markers. Identify service, flow direction (when applicable), and pressure (when applicable). Install in clear view and align with axis of piping and ductwork. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction. Lettering shall be large enough to read from the floor.
- E. Include identification of piping content in same designations used on the drawings.
- F. Identify closed loop hydronic system volume with tag that indicates system volume at the makeup water connection to the system. Affix with a non-corroding metal chain similar to valve tags.

3.6 LAMINATED DIAGRAMS

- A. Prepare a laminated piping diagram for mounting in each mechanical room and placement in the Operation and Maintenance Manuals. This piping diagram must be documented on a reduced floor plan, updated as required, showing all piping and valves location with valve identification. Piping shall be color-coded or otherwise identified by type (natural gas, steam, etc.).
- B. Laminated Diagram-Control Cabinets
 - 1. Provide laminated in control panels associated with major equipment.
 - 2. Control panel wiring diagrams shall be laminated and permanently affixed to the inside of each control panel furnished by the Building Automation System even if paper size needs to be reduced to accommodate piping diagram.

3.7 CEILING AND ACCESS PANEL IDENTIFICATION

- A. All equipment above the ceiling requiring access and/or periodic services shall be labeled on the ceiling grid or access panel with nameplates sized to suit ceiling grid. Ideal label sizes are 0.75"x1.5" but may need to be adjusted for tee widths. Labels shall be laminated plastic with engraved white letters on a black background.

- B. Located in tee closest to equipment location.
- C. All valves concealed above a ceiling shall be labeled on the ceiling grid. Equipment isolation valves associated with terminal unit equipment that is already labeled on the grid do not need to be labeled if accessed from the same ceiling tile.
- D. For special ceilings such as wood or metal panel, the engineer shall provide proposed labeling for these finishes and obtain approval from the Owner's Representative.

3.8 CONTROLS AND INSTRUMENTATION

- A. See preceding information in this section for labeling of panels, equipment and valves.
- B. All junction boxes are to be painted yellow. Conduit must be tagged or marked with at least four inches (4") long yellow sections at twenty feet (20') maximum intervals.

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Testing, adjusting, and balancing of environmental systems including but not limited to air distribution, hydronics, domestic hot water recirculating systems, pure water recirculating systems and other miscellaneous systems, and the equipment and apparatus connected thereto.

1.2 DESCRIPTION

- A. The Contractor shall secure the services of an independent Testing, Adjusting and Balancing (TAB) agency for the TAB of the mechanical systems as specified herein.

1.3 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230923 – Direct-Digital Control for HVAC

1.4 REFERENCES

- A. AABC - National Standards for Total System Balance
- B. ADC - Test Code for Grilles, Registers, and Diffusers
- C. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-conditioning, and Refrigeration Systems
- D. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems
- E. SMACNA - HVAC Systems Testing, Adjusting, and Balancing

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Balancing Agency Information: Include name of balancing agency, documentation of either AABC or NEBB certifications and list of relevant project experience.
- B. Submit signed guarantee of conformance of work with either AABC or NEBB standards as outlined in the Quality Assurance section of these specifications.
- C. Submit proposed data sheets for each different type of equipment and system.

- D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 FIELD REPORTS (REFER TO SECTION 230500)

- A. Submit when deficiencies in systems prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance. Indicate deficiencies in the report.
- B. Submit report prior to preparation of balancing report.

1.7 DATA SHEETS

- A. Indicate data on AABC National Standards for Total System Balance forms or NEBB forms or an exact reproduction thereof.
- B. Data sheets shall, at a minimum, indicate design and actual conditions for all information included in the equipment schedules on the drawings.

1.8 PRELIMINARY AND FINAL BALANCE REPORTS

- A. Submit two (2) draft copies of preliminary balance report for review prior to final acceptance of Project for review.
- B. Make required corrections to the TAB report and provide three (3) final copies of the balance report, one (1) for Architect/Engineer, and two (2) for inclusion in operating and maintenance manuals.
- C. Provide Architect/Engineer's final report in soft cover, letter size, securely bound manuals, complete with index page, indexing tabs, and cover identification. Reports for inclusion in the operating and maintenance manuals shall meet the same requirements, except binding shall be coordinated with the operation and maintenance manuals.

1.9 SUBMITTALS AT PROJECT CLOSEOUT (REFER TO SECTION 230500)

- A. Provide final balance reports for inclusion in the operation and maintenance manuals as described above.

1.10 REGULATORY REQUIREMENTS

- A. Perform total system and equipment balance in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance or NEBB Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.11 QUALIFICATIONS

- A. Agency: Company specializing in the testing, adjusting, and balancing of systems specified in this section with a minimum of five (5) years, documented experience.
- B. Perform work under the supervision of an AABC Certified Test and Balance Engineer or NEBB Certified Testing, Balancing and Adjusting Supervisor.

1.12 PRE-BALANCING CONFERENCE

- A. Convene at project site one (1) week prior to commencing work of this section, under provisions of Section 230500.

1.13 COORDINATION

- A. See Section 230500 for required interface between the sheetmetal, plumbing, and control contractor, and balance agency.

1.14 ACCEPTABLE TOLERANCES

- A. All systems and equipment shall be adjusted to within plus or minus 10 % of design conditions.

1.15 APPROVED AGENCIES

- A. Approved Agencies (Refer to Section 230500)
 - 1. Testcomm
 - 2. Or Approved Equal
- B. Agencies seeking approval for the Testing and Balancing work shall submit for approval during the bid period as specified in Section 230500. The request for substitution shall contain the following information. Requests lacking this information will not be approved.
 - 1. Certification of membership with AABC or NEBB
 - 2. Representative list of projects with at least five projects of similar size and scope to this project.
 - 3. Design Engineer and Owner references - a minimum of two of each

PART 2 - (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure that the items on the pre-balance checklist are completed.
- B. Submit field reports as required to report defects and deficiencies noted during performance of services which prevent system balance.

3.2 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations.

3.3 PROCEDURES

- A. All procedures shall be in accordance with and meet all the requirements of either AABC or NEBB procedural standards. The requirements listed in this section are intended to be supplementary to the requirements of these standards.
- B. Supplemental Requirements
 - 1. Ensure recorded data represents actual measured or observed conditions.
 - 2. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
 - 3. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
 - 4. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
 - 5. At project closeout, Balancing Agency shall be represented at final observation meeting by qualified testing personnel with balancing equipment and two (2) copies of air balancing test report.
 - a. Owner's Representative may choose and direct spot balancing of one zone. Differences of 10 % or more between the spot balance and test report will be justification for requiring repeat of testing and balancing for entire building.
 - b. Re-balancing shall be done in presence of Owner's Representative or Engineer and subject to their approval.
 - c. Spot balance and re-balance shall be performed at no additional cost to Owner. The Contractor shall compensate the Owner's Representative for additional time and expense incurred.

3.4 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide design supply, return, outside air, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct. Traverse shall be used for fan total airflow measurement and calibration of airflow measuring stations and terminal units. Branch traverses shall be totalized where a single traverse is not feasible. Any other method of total airflow measurement shall be approved by engineer.
- C. Vary total system air quantities by adjustment of fan speeds.
- D. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters. In cooperation of Section 230923, set adjustments of automatically operated dampers as specified, indicated or noted.
- E. Adjust outside air dampers, outside air, return air, and exhaust dampers for design conditions.
- F. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- G. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

3.5 HYDRONIC SYSTEM WATER SYSTEM PROCEDURE

- A. Preparation of System - Phase I
 - 1. Open valves fully, including coil stop valves and return line balancing cocks. Close bypass valves.
 - 2. Examine water in system to determine if it has been treated and is clean.
 - 3. Check pump rotation.
 - 4. Check expansion tanks to make sure they are not waterlogged or air bound and system is full of water.
 - 5. Make certain air is removed from circulating system.
 - 6. Set controls to insure full flow thru coils and equipment. If both heating and cooling is involved, each system shall be balanced in the full flow conditions.
 - 7. Check operating temperature of chilled water & heat exchangers.
- B. Performance of Testing and Balancing - Phase II
 - 1. Set circulating pumpsto proper g.p.m. delivery.
 - 2. Adjust flow of water through heat exchangers and other equipment.
 - 3. Check leaving water temperatures, return water temperatures, and pressure drop through equipment. Reset to correct design temperatures.
 - 4. Upon completion of flow readings and coil adjustments, mark settings and record data.

- C. Performance of Testing and Balancing - Phase III
 - 1. After making adjustments to equipment, recheck settings at pumps and equipment. Re-adjust if required.
 - 2. Check water temperature at inlet side of cooling coils. Note rise or drop of temperatures from source.
 - 3. Set controls to minimum position to insure flow through bypass pipes to achieve identical flow rates as that through the coils or equipment.
 - 4. Follow same procedure for all 3-way and bypass valves.

- D. Pumps which can deliver more than 10% over design flow at the actual system pressure experienced under installed conditions shall have impellers trimmed so that flow is 110% of design flow at full hertz. Test agency shall make recommendations to plumbing contractor regarding pump impeller changes.

- E. Check and record data at each cooling and/or heating element and circulating pump. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts. Alternatively, when parallel pumps have been provided, multiple pumps can be operated simultaneously to provide 100% design system flow provided that both pumps can be operated without damage to the system. Where pressure independent balancing valves are used, record valve information (manufacturer, size, and flow), record pressure at device, and verify it is within the range of the valve and that minimum pressures are satisfied. Fluid differential temperature across the coil shall be recorded on the balance form.

3.6 SCHEDULES

- A. Equipment Requiring Testing, Adjusting, and Balancing
 - 1. HVAC Pumps
 - 2. Cooling Coils
 - 3. Air Handling Units
 - 4. Split Systems
 - 5. Heat Exchangers
 - 6. Variable Frequency Drives

- B. Report Forms
 - 1. Title Page:
 - a. Name of Testing, Adjusting, and Balancing Agency
 - b. Address of Testing, Adjusting, and Balancing Agency
 - c. Telephone number of Testing, Adjusting, and Balancing Agency
 - d. Project name
 - e. Project location
 - f. Project Architect
 - g. Project Engineer
 - h. Project Contractor
 - i. Project altitude

- j. Report date
2. Summary Comments:
- a. Design versus final performance
 - b. Notable characteristics of system
 - c. Description of systems operation sequence
 - d. Summary of outdoor and exhaust flows to indicate amount of building pressurization.
 - e. Nomenclature used throughout report
 - f. Test conditions
3. Instrument List:
- a. Instrument
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Range
 - f. Calibration date
4. Electric Motors:
- a. Manufacturer
 - b. Model/Frame
 - c. HP/BHP
 - d. Phase, voltage, amperage; nameplate, actual, no load
 - e. RPM
 - f. Service factor
 - g. Starter size, rating, heater elements
 - h. Sheave Make/Size/Bore
5. Pump Data:
- a. Identification/number
 - b. Manufacturer
 - c. Size/model
 - d. Impeller
 - e. Service
 - f. Design flow rate, pressure drop, BHP
 - g. Actual flow rate, pressure drop, BHP
 - h. Discharge pressure
 - i. Suction pressure
 - j. Total operating head pressure
 - k. Shut off, discharge and suction pressures
 - l. Shut off, total head pressure
6. Heat Exchangers:
- a. Identification/number

- b. Manufacturer
 - c. Capacity
 - d. Model number
 - e. Serial number
 - f. Water side flow rate, design and actual
 - g. Water side pressure drop, design and actual
7. Cooling Coil Data:
- a. Identification/number
 - b. Location
 - c. Service
 - d. Manufacturer
 - e. Air flow, design and actual
 - f. Water flow, design and actual
 - g. Water pressure drop, design and actual (where applicable)
8. Air Moving Equipment
- a. Location
 - b. Manufacturer
 - c. Model number
 - d. Serial number
 - e. Arrangement/Class/Discharge
 - f. Supply air flow, specified and actual
 - g. Return air flow, specified and actual
 - h. Outside air flow, specified and actual
 - i. Total static pressure (total external), specified and actual
 - j. Inlet pressure
 - k. Discharge pressure
 - l. Sheave Make/Size/Bore
 - m. Number of Belts/Make/Size
 - n. Fan RPM
 - o. On systems with supply and return or exhaust fans record offset volumes used for system pressurization. On variable volume systems, forward offset volumes to the EMCS contractor for input into their programming for return fan tracking.
 - p. On AH and HR systems record heat exchanger and filter air pressure drops.
9. Duct Traverse:
- a. System zone/branch
 - b. Duct size
 - c. Area
 - d. Design velocity
 - e. Design air flow
 - f. Test velocity
 - g. Test air flow
10. Variable Frequency Drives

- a. Mfr, size, amp rating, heater/fuse settings
- b. Control pressure
- c. Critical zones (top 3 driving the control pressure setpoint)
- d. VFD speed (hz) and amps at maximum design conditions
- e. VFD speed (hz) and amps at minimum design conditions

3.7 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 0593

SECTION 23 0700 - HVAC INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe and Equipment Insulation
- B. Inserts and Shields – Installation
- C. Jackets and Fitting Covers

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230517 – Sleeves and Sleeve Seals for HVAC
- C. Section 230523 – General Duty Valves for HVAC Piping
- D. Section 230529 – Hangers and Supports for HVAC Piping and Equipment
- E. Section 230553 – Identification for HVAC Piping and Equipment
- F. Section 232113 – Hydronic Piping
- G. Section 232300 – Refrigerant Piping

1.3 REFERENCES

- A. General
 - 1. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials
 - 2. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials
 - 3. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials
 - 4. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials
 - 5. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
 - 6. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation
 - 7. ASTM C665-Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
 - 8. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

9. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials
10. ASTM E162 - Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source
11. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi
12. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials
13. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
14. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials

B. Cellular Foam

1. ASTM C534 - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
2. ASTM D1056 - Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber

C. Cellular Glass

1. ASTM C552 – Standard Specification for Cellular Glass Thermal Insulation

D. Glass Fiber

1. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation

E. Jackets and Fitting Covers

1. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
2. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation
3. ASTM D1784 - Standard Specification for Rigid PolyVinyl Chloride (PVC) Compounds Chlorinated PolyVinyl Chloride (CPVC) Compounds

F. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

G. Applicator Qualifications: Company specializing in performing the work of this section with minimum three (3) years documented experience and who is authorized by the manufacturer.

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

A. General

1. For each insulation type, provide material characteristics, minimum and maximum service temperatures, moisture absorption characteristics, thermal and vapor transmission characteristics.
2. Provide a schedule indicating insulation type and thickness for each specific pipe, equipment and duct system and installation type.

1.5 REGULATORY REQUIREMENTS

A. General

1. Conform to flame spread/smoke developed rating of 25/50 in accordance with ASTM E84, NFPA 255, and UL 723. This shall apply to insulation as well as to all accessories including but not limited to adhesives, mastics, jackets, cements, tapes, cloth for fittings, etc.
2. Material packaging shall be clearly UL labeled for the intended purpose.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Section 230500.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of twenty-four (24) hours.

PART 2 - PRODUCTS

2.1 CELLULAR FOAM (PIPING)

- A. Manufacturers (Refer to Section 230500):
 1. Armstrong, Armaflex-AP
 2. Halstead
- B. Insulation: ASTM C534; flexible; cellular elastomeric; molded or sheet; *k* factor: ASTM C177, 0.27 Btu·in/(h·ft²·°F) at 75 °F; -70 °F minimum service temperature; 220 °F maximum service temperature; maximum moisture absorption: ASTM D1056, 5.0 percent (pipe) by weight; 6.0 percent (sheet) by volume; moisture vapor transmission: ASTM E96, 0.10 perm-inches.
- C. Connection: Waterproof vapor barrier contact adhesive compatible with the insulation. Armstrong 520 adhesive or approved equal.

2.2 GLASS FIBER (PIPING)

- A. Manufacturers (Refer to Section 230500):
 - 1. Johns Manville, Micro-Lok, AP-T Plus
 - 2. Knauf
 - 3. Owens Corning
- B. Insulation: ASTM C547; rigid molded; noncombustible; *k* factor: ASTM C177, 0.24 Btu·in/(h·ft²·°F) at 75 °F; 850 °F maximum service temperature; 0.2 percent maximum moisture absorption by volume.
- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn; bonded to aluminized film with pressure sensitive tape lap sealing system; moisture vapor transmission: ASTM E96; 0.02 perm-inches.
- D. Provide with GreenGuard Certification for Children and Schools.

2.3 CELLULAR GLASS (PIPING)

- A. Manufacturers: Pittsburgh Corning FOAMGLAS
- B. Insulation: ASTM C552; rigid; cellular glass; molded or sheet. Insulation material and jacketing shall be the same for fittings as for pipe.
 - 1. *k* factor (ASTM C177): 0.29 Btu·in/(h·ft²·°F) at 75 °F
 - 2. Minimum service temperature: -10 °F
 - 3. Maximum service temperature: 900 °F
 - 4. Maximum moisture absorption (ASTM C240): 0.2% percent by volume
 - 5. Moisture vapor transmission (ASTM E96): 0.00 perm-inches
 - 6. Combustibility: Noncombustible (ASTM E 136)
 - 7. Flame Spread/Smoke developed (ASTM E 84): 0/0
 - 8. Density (ASTM C 303): 7.5 lb/cu.ft.
- C. Jacketing: PITTWRAP CW Plus
 - 1. 1.5 mil thick self-sealing, polymer modified bituminous compound membrane reinforced with a glass fabric and a 1 mil aluminum top film and release paper backing.

2.4 JACKETS AND FITTING COVERS (PIPING)

- A. PVC Plastic Jacket and Fitting Covers (Interior Applications):
 - 1. Manufacturers (Refer to Section 230500):
 - a. Zeston 2000
 - b. Speedline Corporation

2. Jackets and fitting covers: ASTM D1784; one-piece molded type fitting covers and sheet material; off-white color; minimum service temperature: 0 °F; maximum service temperature: 450 °F; thickness: 20 mil.
 3. Jackets and fitting covers (vapor barrier jackets): ASTM D1784; one-piece molded type fitting covers and sheet material; off-white color; minimum service temperature: 0 °F; maximum service temperature: 450 °F; moisture vapor transmission - ASTM E96 - 0.002 perm-inches; thickness: 20 mil.
 4. Connections: Pressure sensitive color matching vinyl tape
- B. Aluminum Jacket (Exterior Applications): ASTM B209
1. Manufacturers (Refer to Section 230500):
 - a. Johns Manville
 2. Jacket: ASTM C1729; thickness: 0.016-inch sheet; 3105 or 3003 aluminum alloy; factory applied and baked on polyester paint: embossed; joining: Longitudinal slip joints and 2-inch laps.
 3. Fittings: 0.016-inch-thick die shaped fitting covers with factory attached protective liner.
 4. Metal Jacket Bands: 3/8 inch wide; 0.015-inch-thick aluminum.

2.5 INSULATION INSERTS FOR PIPE SHIELDS AND SADDLES

- A. Insulation Inserts:
1. At pipe shields:
 - a. Extra heavy density insulation which will not crush from weight of pipe.
 - b. Thickness same as scheduled for pipe insulation
 - c. Cover no less than 40% of the circumference of the insulation for pipe supported from hangers. Cover 100% of the circumference of the pipe for pipe supported on trapeze.
 - d. Pittsburg-Corning Foamglas, Calcium Silicate or approved equal.
 - e. Length to match shield length. Coordinate with Section 230529.
 2. At Saddles
 - a. Pittsburg-Corning Foamglas, Calcium Silcate or approved equal.
 - b. Pre-cut pipe insulation to fit within saddle to maintain insulation integrity of pipe at the saddle location.
 - c. Lengths to match saddle length.
- B. Inserts: Heavy density insulation which will not crush from weight of pipe. Locate between shield and pipe. Inserts are furnished in this Section 230700 and installed in Section 230529.
- C. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and insulation. Shields are furnished and installed under Section 230529.

2.6 GLASS FIBER (EQUIPMENT)

- A. Manufacturers (Refer to Section 230500):
 - 1. Johns Manville - Pipe and Tank Insulation
 - 2. Owens Corning
- B. Insulation: Semi-rigid, noncombustible; *k* factor: ASTM C335 0.27 Btu·in/ (h·ft²·°F) at 75 °F; maximum service temperature: 650 °F; density: 3.0 pounds/foot³.
- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film with pressure sensitive tape lap sealing system; moisture vapor transmission: ASTM E96; 0.02 perm-inches.

2.7 LACE-ON BLANKETS

- A. Manufacturers (Refer to Section 230500):
 - 1. Insulation
 - a. Kaowool Cerablanket
 - 2. Fabric (White Finish)
 - a. JP Stevens Glass-Tex Fabric Style 9987
 - b. Alpha Maritex Style 3200-SA
- B. Materials: 0.008-inch-thick type 304 stainless steel knitted wire mesh inner liner 8 pounds/foot³ density insulation, ½ inch thick; oil and water resistant exterior protective (white) fabric.
- C. Construction: Blankets shall be sewn together. Lacing anchors shall be 2½ inch stainless steel secured with 12-gauge stainless steel washers. Blankets shall have stainless steel wire installed for draw cords.

2.8 REUSABLE VALVE COVERS (HYDRONIC PIPING) (INDOOR ONLY)

- A. Manufacturers (Refer to Section 230500):
 - 1. No Sweat Valve Wraps
- B. Product shall be engineered for a wide variety of valves including strainers, automatic balancing devices, circuit setters, ball valves, butterfly valves, control valves and check valves. Product consists of outer jacket, closure assembly and fiberglass insulation.
- C. Outer jacket shall be made of material equal to DuPont Tychem® QC, overlapping and completely covering the insulation with seams joined by tabs made from hook and loop fasteners (Velcro). Butt ends shall have sewn-in-place elastic. Weight of 2.5 oz per square

yard, 10 mils thickness, 0.01 Perms water vapor transmission, 65 psi Mullen burst strength, white/glass finish, UV resistant

- D. Outer jacket shall overlap adjoining sections of pipe insulation.
- E. Installation shall not require the use of any special hand tools.
- F. Suitable for continuous operation at 200 degrees Fahrenheit with insulation insert blankets
- G. Fire and smoke performance: Flame spread less than 25, smoke developed less than 50 per ASTM E84.
- H. Insulation Inserts: Fiberglass k-factor 0.26 per inch (ASTM C77). Provide 1 or more layers to meet or exceed minimum insulation thickness requirements as indicated in pipe schedules in Part 4 of this specification.

PART 3 - EXECUTION

3.1 EXAMINATION – GENERAL

- A. Verify that piping and ductwork has been tested and approved before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION – GENERAL – (PIPING)

- A. Continue insulation with vapor barrier through penetrations.
- B. On exposed piping in finished areas, locate insulation and cover seams in least visible locations.
- C. Insulate pipes in accordance with the insulation schedule.
- D. On insulated piping with vapor barrier, insulate fittings, valves, unions, flanges, strainers, flexible connections and expansion joints.
- E. On insulated piping without vapor barrier for pipes conveying fluids 180° F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation at such locations.
- F. Install materials in accordance with the manufacturer's instructions.
- G. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
- H. Insulation on all cold water systems shall be applied with a continuous unbroken vapor seal. Do not allow hangers, supports, anchors etc., to come in direct contact with the pipe.

- I. Insulate entire system including fittings, unions and flexible connections, flanges and expansion joints. For insulation of valves and other pieces of equipment, see Section 230700. At fire separations, Refer to Section 230517.

3.3 CELLULAR FOAM INSULATION (PIPING)

- A. Cover pipe and fittings with insulation in thickness scheduled.
- B. Insulation shall fit in snug contact with pipe and be installed in accordance with the manufacturer's recommendations.
- C. Slip insulation on tubing before tubing sections and fittings are assembled keeping slitting of insulation to a minimum.
- D. Seal joints in insulation with adhesive.
- E. Insulate fittings with pre-molded covers or sheet insulation.
- F. Stagger joints on layered insulation.
- G. Insulation exposed outside shall have "slit" joint seams places on the bottom side of the pipe.
- H. Paint exterior exposed insulation with two coats of gray finish recommended by the Insulation manufacturer to protect from weather and sunlight.

3.4 GLASS FIBER INSULATION (PIPING)

- A. Cover pipe with glass fiber insulation in thickness scheduled.
- B. When vapor barrier is required, adhere factory applied vapor barrier jacket lap smoothly and securely at longitudinal laps with pressure sensitive strip. Adhere self-sealing butt joint strips over end joints. No staples will be allowed.
- C. Insulate fittings and joints with molded insulation of like material and thickness of adjacent pipe with ends of insulation tucked snugly into throat of fitting and edges adjacent to pipe insulation tufted and tucked in.
- D. Cover insulation with one piece PVC fitting covers.

3.5 CELLULAR GLASS INSULATION

- A. Cover pipe with cellular glass insulation in thicknesses scheduled on drawings.
- B. Install in accordance with the manufacturer requirements. Install specified jacket materials over insulation in accordance with the manufacturer requirements.

3.6 JACKETS AND FITTING COVERS (PIPING)

- A. Apply insulation prior to installation of jackets and fitting covers.
- B. Insulated pipe located outdoors and insulated pipe penetrations through exterior walls: finish with aluminum jacket and fitting covers.
- C. Pipe exposed in finished spaces, including mechanical rooms when less than 10 feet above finished floor, or where indicated on drawings: finish with PVC jacket and fitting covers. Seams shall be installed in least visible location.
- D. Secure PVC jackets and fitting covers with stainless steel tacks and wrap seams and tacks with vinyl tape.
- E. Install aluminum jackets located outdoors with seams located on bottom side of horizontal piping. Apply sealing compound and closures to make weathertight.

3.7 INSERTS AND SHIELDS

- A. Insulation inserts are furnished in this section and provided to Section 230529 for installation.
- B. Install finished piping insulation tight to inserts with tightly fitting butt joints. Maintain continuous vapor barrier and jacketing at pipe joints

3.8 INSTALLATION – GENERAL – (EQUIPMENT)

- A. General
 - 1. Provide materials in accordance with the manufacturer's recommendations.
 - 2. Factory Insulated Equipment: Do not insulate.
 - 3. Finish insulation at supports, protrusions, and interruptions.
 - 4. Nameplates and ASME Stamps: Bevel and seal insulation around with a mastic. Do not insulate over.
 - 5. Exposed Equipment in Finished Areas: Locate insulation and cover seams in least visible locations.
 - 6. Cover field insulated tanks with white PVC plastic jacket.
- B. Hydronic Valve Covers: For indoor hydronic valves requiring access for maintenance, repair or cleaning: Insulate with reusable valve covers. Install insulation in single or multiple layers to match scheduled insulation thickness.
- C. Outdoor Hydronic Valve Covers: Insulate with Lace-On Blanket. Install insulation in single or multiple layers to match scheduled insulation thickness. Blankets shall be removable and re-useable.

3.9 CELLULAR FOAM (EQUIPMENT)

- A. For equipment not requiring access for maintenance, repair or cleaning.
- B. Cover equipment in thickness scheduled.
- C. Insulation shall fit in snug contact with equipment and be installed in accordance with the manufacturer's recommendations.
- D. Seal joints in insulation with adhesive.
- E. Stagger joints on layered insulation.
- F. Paint exterior exposed insulation with two coats of gray finish recommended by the Insulation Manufacturer to protect from weather or sunlight.

3.10 GLASS FIBER (EQUIPMENT)

- A. For equipment not requiring access for maintenance, repair or cleaning.
- B. Cover equipment with glass fiber insulation in thickness scheduled.
- C. Provide vapor barrier jackets. Adhere factory applied vapor barrier jacket lap smoothly and securely at longitudinal laps with pressure sensitive strip. Adhere self-sealing butt joint strips over end joints. No staples will be allowed.

3.11 LACE-ON BLANKETS

- A. Provide for equipment requiring access for maintenance, repair, or cleaning: insulate with lace on blanket.
- B. Install in single or multiple layers to match scheduled insulation thickness for associated piping system.
- C. Blankets shall be removable and reusable.

3.12 VALVE COVERS

- A. Install in accordance with manufacturer requirements
- B. Schedule:
 - 1. Outdoor valves: Provide lace-on blankets.
 - 2. Indoor hydronic valves: Provide lace-on blankets or reusable valve covers.
- C. Installation shall not require the use of special tools.

PART 4 - SCHEDULES

4.1 SCHEDULES

- A. Insulate heating and cooling equipment including valves, tanks, traps, air removal devices, flash tanks, etc.
- B. Insulate pumps which deliver fluid below ambient temperature.
- C. Equipment, tanks, etc., not factory insulated, shall be insulated under this section.
- D. Expansion tanks and similar equipment not receiving fluid directly from the system do not require insulation.
- E. Valves, traps, pressure reducing valves, pumps, convertors, expansion joints, etc.: Extend insulation 6 inches beyond flanges.
- F. Systems above Ambient Temperature: 2-inch-thick glass fiber insulation with vapor barrier.
- G. Systems below Ambient Temperature: ½ inch thick glass fiber insulation with vapor barrier. Exception: Insulate pump bodies on systems below ambient temperature with 1-inch-thick cellular foam insulation.
- H. All equipment requiring access for maintenance, repair or cleaning shall be insulated with lace-on blankets.

Insulation Schedule - Piping					
System	Operating Temperature (degrees F)	Insulation Type	Pipe Size (inches)	Minimum Insulation Thickness (inches)	Notes
Chilled Water (Above Ground: Campus Chilled Water, Glycol Chilled Water)	40 to 60	glass fiber k = .21 - .27	Under 1 ½	0.5	2
			1 ½ and greater	1	
Refrigerant	40 to 60	cellular foam k = .22 - .28	Under 1 ½	0.5	—
			1 ½ and greater	1	
Notes:					

END OF SECTION 23 0700

SECTION 23 0800 - MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. System specific commissioning for the HVAC, Building Management Control.

1.2 DESCRIPTION OF WORK – REFER TO SECTION 019113

1.3 SUBMITTALS – REFER TO SECTION 019113

PART 2 - PRODUCTS – REFER TO SECTION 019113

PART 3 - EXECUTION

3.1 SYSTEMS READINESS PROCESS

A. Review and Complete Systems Readiness Checklists in accordance with Section 230800.

B. Minimum Start-Up Requirements

1. At a minimum, in addition to manufacturer recommended start-up procedures, contractor Field Start-Up activities shall include:
 - a. Belt Tension demonstration before first operation of motor according to Gates Rubber Co. PT/Toolkit. (Belt Driven Equipment)
 - b. Meggering Motors controlled by VFD or motors larger than 5HP regardless of control. Readings less than 1MegaOhm shall be a threshold for rejection of electrical insulation on feeder conductors.
 - c. Sheave and Pump shaft alignment with laser. (Belt Driven and Pump Coupled Equipment)
 - d. For VFD driven motors, tachometer readings shall be taken with external meter and used to calibrate VFD speed readings.
 - e. AHU vibration readings shall be taken after equipment is installed on site and must comply with operational readings of no more than 0.2 in/sec as measured in the horizontal and vertical directions after the equipment has been permanently installed. If the assembly fails, a dynamic balance shall be performed by permanently affixing weights to counter the imbalance present.

- C. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
- D. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work.
- E. The Systems Readiness Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere

3.2 SYSTEMS READINESS PLAN

- A. The Contractor shall provide a system readiness manual, which shall include the following:
 - 1. Systems Readiness Checklists – provided by CxA and completed by the Contractor
 - 2. Startup and testing procedures and data forms, in accordance with the project specifications, for all equipment and systems within the commissioning scope of work
 - 3. Piping and duct testing reports, to be approved by the AE
 - 4. Water treatment reports to be approved by the AE
- B. Within 20 working days of Product Submittal approval, submit the Systems Readiness Plan with blank forms for CxA review.
- C. Submit the completed readiness manual prior to functional performance testing. When it is necessary to begin functional performance testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the Systems Readiness Plan that have been completed only for the system(s) that are ready for testing.

3.3 TAB REVIEW

- A. Testing, Adjusting and Balancing (TAB): TAB shall be provided by the Contractor in accordance with the project specifications. The TAB contractor shall support commissioning by submitting the preliminary TAB data for CxA review and participating on the Commissioning TAB Field Review, in which the TAB Contractor demonstrates specified results to the CA after completion of final TAB.
- B. Equipment tested: All HVAC systems & equipment
- C. Demonstrate:
 - 1. Determination of the final setpoints for pump speed and fan speed control per the project specifications, NEBB and AABC standards. Demonstrate for all setpoints.
 - 2. Airflow rates are balanced and adjusted per the project specifications, NEBB and AABC standards
 - a. Demonstrate minimum outside airflow rates for all air handling equipment

- b. Demonstrate a 10% sample for all other measurements
- 3. Hydronic system flow rates are balanced and adjusted per the project specifications and AABC standards.
 - a. Demonstrate for all boilers, chillers, cooling towers, and distribution pumps
 - b. Demonstrate a 10% sample for all other measurements.
- 4. Verify TAB of circulating domestic hot water system per the project specifications, NEBB and AABC standards. Demonstrate a 10% sample

3.4 FUNCTIONAL PERFORMANCE TESTING

- A. The Functional Performance Test (FPT) Procedures shall be developed, performed, and demonstrated.
- B. At a minimum, the contractors and equipment suppliers listed in the FPTs Minimum Participants Table in this section of the specifications are required to participate in developing, performing, and demonstrating the indicated FPTs.
- C. The Contractor's Commissioning Coordinator shall coordinate the subcontractors, with the Commissioning Authority's input, in developing, performing, and demonstrating the Working FPT.
- D. Functional testing shall consist of the following four phases:
 - 1. Component testing:
 - a. Component testing applies to all control input and output devices, including those provided the equipment suppliers and those provide with the Energy Management and Control System (EMCS). Examples include but are not limited to: sensor assemblies, detectors, relays and switches, valves, dampers, and actuators
 - b. Component testing applies to thermometers, gauges:
 - c. Component testing consists of demonstrating field I/O calibration and operation including but not limited to:
 - 1) Accuracy of sensors is within design temperature range as specified.
 - 2) Alarmed points report correctly to operator work station.
 - 3) Accuracy and settings of binary switches and alarms is as specified, within design temperature range
 - 4) Actuators operate smoothly in a linear relationship with the signal they receive over the full range of operation
 - 5) Fail safe operation of components and controllers is as specified for loss of control signal, electric power, and network communications
 - 6) All components, values and alarms are correctly mapped to operator interface station

2. Systems Testing; Operational Verification: After demonstrating acceptable component functionality, and prior to demonstrating real-time performance, a sequence of operation test shall demonstrate that the programming used for each type of equipment acceptably implements the specified sequence of operation. When identical software programming is used to control multiple similar systems, the sequence of operation test shall be performed on a random selection of 10% of the equipment, but at least 2 systems, which shall be chosen by the commissioning agent at the time of the test demonstration. Real-time performance for each system must be demonstrated as described under "Systems Testing; Real Time Performance Demonstration (trend logging)" in a subsequent paragraph
3. Systems Testing – Integrated System Verification: After operational testing has successfully demonstrated that each system functions in accordance with the project documents, functional testing shall occur to verify that the interaction between the systems is as required. Each interactive function shall be functionally tested, including those provided the equipment suppliers and those provide with the Energy Management and Control System (EMCS).
4. Systems Testing – Real Time Performance Analysis (trend logging):
 - a. After operational testing has been successfully completed real time performance testing shall be performed. Data shall be logged for the intervals and periods specified in the FPT procedures. Unless otherwise specified in the FPTs, test periods shall include occupied, unoccupied, weekend, and holiday schedules.
 - b. Analysis of the data shall demonstrate that that the systems operate in accordance with the acceptance criteria specified in the FPT procedures. Verify that data demonstrates acceptable results before submitting for CA review. If acceptable results are not demonstrated, perform testing and trouble shooting and corrective action to provide resolution.
 - c. In addition to the initial test period, data shall be logged during a peak heating period, a peak cooling period, and a transitional season period if so specified under FUNCTIONAL PERFORMANCE TEST (FPT) SEASONAL TESTING

- E. The Systems Readiness Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere.

3.5 FPTs MINIMUM PARTICIPANTS TABLE:

- A. The following table lists the FPTs, and the subcontractors and suppliers that are required to participate in their development and performance.
- B. The key to the codes used in the minimum participants column of the table is as follows:

M = Division 23 (Mechanical) subcontractor,
D = Division 230923 Energy Management and Control System subcontractor,
T = Testing Adjusting and Balancing subcontractor,
F = Fire Alarm System subcontractor
A = Air Handling Unit Supplier and Startup Technician
P = Packaged Split System Air Conditioning Supplier and Startup Technician

V = Variable Frequency Drive Startup Technician

FPT (SPEC) NUMBER 230800	FPT PROCEDURE	MINIMUM PARTICIPANTS
	AIR TERMINAL AND MISCELLANEOUS	
Z-1.1	Temperature Sensors	D
Z-1.4	Current Sensing Relays	D
Z-1.6	Modulating Control Valves	D
Z-1.7	Filter Differential Pressure Switches	D
Z-1.8	Duct Smoke Detector	D, M
Z-5.0	Split Systems A/C, Heat Pump	D
	AIR HANDLING	<i>SE</i>
A-1.3	Duct Pressure Sensors, Pressure Limit Switches, Diff Pressure Switches	D, M
A-1.4	Air Flow Stations	D, M, T
A-1.5	Low Limit Thermostats	D, M
A-1.6	Modulating Control Valves	D, M
A-1.7	Modulating Control Dampers	D, M
A-2.0	ALL Air Devices – start/stop schedule, Interlocks, Safeties	D, M
A-2.1.2	AHU Operation	D, M
	INTER-SYSTEM TESTS	
CC-2.0	Fire System Shutdown – HVAC Interaction	F, D, M

1.1 FUNCTIONAL PERFORMANCE TEST (FPT) SEASONAL TESTING

- A. Perform seasonal testing in accordance with the specification for Real Time Performance Analysis, which is specified elsewhere in this section.
- B. The following table indicates which FPTs include Seasonal Testing.

- C. The key to the codes used in Seasons column of the table is as follows: W = winter/peak heating; SU = summer/peak cooling; SP = spring/heating to cooling transitional season; F = fall/cooling to heating transitional season

FPT (SPEC) NUMBER 23 0800 -	FPT PROCEDURE	SEASON
DX2.1	DX Cooling	Winter/Summer
C2.1	Chilled Water	Winter/Summer

- D. SYSTEMS READINESS CHECKLISTS: Shall be created by the CxA and given to the contractors at the Construction Phase Cx Kickoff meeting and after the approved equipment submittals have been returned by the Design Team to the contractors.
- E. FUNCTIONAL PERFORMANCE TEST PROCEDURES: Shall be created by the CxA and given to the contractors for review after the approved equipment submittals have been returned by the Design Team to the contractors. After written acceptance from the contractors as defined in Section 019113, the final tests will be distributed to the contractors prior to equipment start-up.

1.2 MONITORING BASED METERING CHECKS;

- A. 2 separate visits at 5-6 and 10-12 months after acceptance. Division 23 Energy and Controls contractor (Section 230923) shall provide site visit and metering troubleshooting time to verify meters are logging correct readings. All Energy and Utility metered trends shall be forwarded to CxA for verification in graphical format.

1.3 ILFI - NET ZERO METERING CHECKS/DOWNLOADS

- A. At 3, 6, 9, and 12 months after commissioning completion the Division 23 Energy and Controls contractor shall provide site visit and metering troubleshooting time to verify meters are logging correct readings as well as data download. All Energy and Utility metered trends shall be forwarded to CxA for verification in graphical format.

END OF SECTION 23 0800

SECTION 23 0923 - DIRECT-DIGITAL CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Energy Management and Control System (EMCS)
- B. Water Flow Meters
- C. Control Valves
- D. Controllers
- E. Temperature Control Dampers
- F. General Components

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230523 – General Duty Valves for HVAC Piping
- C. Section 230553 – Identification for HVAC Piping and Equipment
- D. Section 230593 – Testing, Adjusting, and Balancing
- E. Section 230995 – Variable Frequency Drives
- F. Section 232113 – Hydronic Piping
- G. Section 232123 – Hydronic Pumps
- H. Section 232300 – Refrigerant Piping
- I. Section 232500 – HVAC Water Treatment
- J. Section 237300 – Central Station Air Handling Units

1.3 REFERENCES

- A. UL 916 - Underwriters Laboratories Standard for Energy Management Equipment
- B. NEC - National Electrical Code
- C. City, county, state, and federal regulations and codes in effect as of date of purchase

1.4 DESCRIPTION

- A. The specification is intended to cover equipment, labor, materials and services sufficient to result in a complete Energy Management and Control System (EMCS) capable of controlling and monitoring the complete mechanical system with owner training as outlined in the drawings and in these specifications.
- B. EMCS contractor shall be responsible for all EMCS and temperature control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes and Division 26. This includes all low voltage wiring as well as line voltage wiring required for control power purposes.

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

A. General

- 1. Drawings shall be standard sizes: 8½×11 inch, 11×17 inch, 24×36 inch.

B. Provide temperature controls submittals with the following tabbed sections:

1. Statements of Conformance Section

- a. Statement of Conformance: The temperature controls submittal shall be accompanied by a statement of conformance by the temperature controls supplier. This statement of compliance shall indicate that the EMCS, as installed, will meet all of the requirements of these specifications. If the EMCS is not capable of meeting each requirement of these specifications, this statement of compliance shall indicate each individual requirement that cannot be met, the impact this might have on the system, and proposed methods of equivalent compliance.
- b. Statement of Native BACnet Conformance: The temperature controls submittal shall be accompanied by a separate statement of native BACnet conformance by the temperature controls supplier. This statement of compliance shall indicate that the EMCS, as installed, will meet all of the requirements of the specified conformance class of native BACnet architecture. Included with this statement shall be Protocol Implementation Conformance Statements (PICS) for each applicable component necessary to demonstrate compliance.

2. Floor Plan Wiring and Component Section

- a. Provide floor plans that indicate the location of primary control components such as operator work stations, equipment controllers/main panels, unitary (terminal unit) controllers, and associated controlled equipment (boilers, chillers, air handlers, etc.).
- b. Provide a network communications (LAN) wiring diagram showing connectivity between control devices.

3. System Interface Section

- a. Provide graphic systems schematics and flow diagrams.
 - b. Provide a complete points list, indicating the plain English description that will be utilized in EMCS programming and the type of point (analog input, analog output, digital input, digital output).
 - c. Provide a complete list of adjustable points, including range of adjustment and initial setting.
 - d. Provide a complete list of alarms, including level of alarm and resulting action.
 - e. Provide a description of the sequences of operation as understood by the controls contractor. This description shall be in the general format of the programming for the controls system, but shall be in narrative form. Copied sequences from the control diagrams are not acceptable.
4. System Wiring Diagram Section
- a. Provide a system schematic layout showing all operators' terminals, equipment controllers, unitary controllers, equipment and systems interface devices, etc. as required for a complete system. The equipment served by each device shall be indicated in the schematic. Individual inputs and outputs shall not be included in this schematic. Each device shown in this schematic shall be cross-referenced to both the individual component schematic as well as the submittal information for that device type. Wiring between devices shall also be cross-referenced to its submittal information.
 - b. Provide individual component schematics for each controller. These schematics shall indicate each device input and output. The available number and type of spare points for each controller as installed as well as the expandability of the device shall be indicated in the schematic.
5. EMCS Software Section
- a. At a minimum, this section shall address each requirement noted in these specifications for the EMCS software.
6. Graphical User Interface Section
- a. Provide a representation of the graphical penetration scheme as outlined in these specifications. This can be in the form of a simple flow diagram.
 - b. Provide a representation of how points and schedules are accessible through the graphical interface.
 - c. Provide a representation of how the system programming is accessible through the graphical user interface.
 - d. Provide information on the graphics development package.
 - e. Provide graphic floor plan displays for all spaces. Include a representation of each of the required space temperature indicators.
 - f. Provide a table of occupied heating, occupied cooling, unoccupied heating and unoccupied cooling setpoints for each temperature control zone. Setpoint criteria shall be obtained from the owner prior to submission of submittals. This table shall be a verification of these criteria.
 - g. Provide a table of the warm-up/pre-cool, occupied and unoccupied scheduling for each temperature control zone. Scheduling criteria shall be obtained from the

owner prior to submission of submittals. This representation shall be a verification of these criteria.

7. Web Browser Interface Section

- a. At a minimum, this section shall address each requirement noted in these specifications for the EMCS software.

8. Interface Wiring Diagrams Section

- a. Provide schematics for each point of interface to other systems or packaged equipment controls.
- b. For interfaces not specified to receive integration devices, provide the following at a minimum:
 - 1) Schematics showing the location of all terminal strips and/or connection points between systems (including room designation, location within room, control panel designation, etc. as appropriate).
 - 2) Notation of contractor responsible for hardware (terminal strips, contacts, etc.), wiring and terminations.
 - 3) A description of each point including plain English functional description, electrical characteristics (0 to 10 V, 4 to 20 mA, N/O dry contact, N/C dry contact, etc.).
- c. For interfaces specified to receive integration devices, provide the following at a minimum:
 - 1) Schematics showing the location of the integration device (including room designation, location within room, control panel designation, etc. as appropriate).
 - 2) Notation of contractor responsible for integration device, wiring and terminations.
 - 3) A description of the information that will be transferable through the integration device, including read/write capabilities.
- d. Each schematic shall be reviewed, approved and noted as such by both the temperature controls contractor and an authorized agent of the system or equipment requiring interface.
- e. At a minimum, a wiring diagram shall be provided for each interface noted in the Systems and Equipment Interfaces section of these specifications.

9. Components Section

- a. Provide submittal information for each system hardware component, including the operator's terminal, all controllers, required systems and equipment interface devices, measurement and control devices. Measurement devices shall include units of measurement, range of measurement and accuracies.
- b. Provide a control damper and damper actuator sizing schedule.
- c. Provide a control valve sizing schedule.
- d. Provide a complete recommended spare parts list for the controls system.

- C. Submit a Material Safety Data Sheet (MSDS) for each sealant, adhesive, coating, paint in accordance with Section 230500.
- D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.
- F. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- G. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Provide "as-built" documentation of all information required for original system and equipment submittals as outlined above. Information shall be included in the operation and maintenance manuals as outlined below.
- B. In addition to inclusion in the operation and maintenance manuals, the points list, adjustable points list, and alarm points list, as required in the systems control section of the submittals, shall be laminated in plastic after approval by Owner's Representative. One copy shall be posted at the main control cabinet of the building and the second copy shall be given to the Owner.
 - 1. Points list shall identify BACnet information and address for each point for use in the future by other BACnet manufacturers.

1.7 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 230500)

- A. The Energy Management and Controls System section shall include the following sub-sections:
 - 1. An individual section for each system. These sections shall include as-built documentation of the information required in the Systems Interface section of the submittals.
 - 2. Systems Wiring Diagrams Section. This section shall include as-built documentation of the information required in the Systems Wiring Diagrams section of the submittals.
 - 3. Interface Wiring Diagrams Section. This section shall include as-built documentation of the information required in the Interface Wiring Diagrams section of the submittals.
 - 4. Components Section. This section shall include as-built documentation of the information required in the components section of the submittals.

1.8 DELIVERY, STORAGE, AND HANDLING (REFER TO SECTION 230500)

- A. Store products in shipping containers in clean, dry location until installation.

- B. The Contractor shall be responsible for his work and equipment until finally inspected, tested, and accepted. The Contractor shall protect any material that is not immediately installed. The Contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

1.9 QUALIFICATIONS

- A. **Manufacturer's/Control Contractor's Qualifications:** The EMCS Contractor shall be a firm that is a factory authorized representative of the manufacturer of the automation and control equipment products, and that is experienced in the design and installation of systems similar in nature to this project, with a record of successful in-service performance.
 - 1. The EMCS Contractor shall have an office located within 150 miles of Ellensburg, WA and shall have at least five (5) years presence of successful project experience in the surrounding area through the same office.
 - 2. The EMCS Contractor shall have successfully designed and installed a minimum of three (3) projects of similar size and complexity.
 - a. Submit project titles, descriptions and contact personnel references (name and phone number) of listed projects.
- B. **Installer Qualifications:** Building automation and temperature control work shall be done by specialty mechanics in the employ of an EMCS contractor who specializes in this work and are factory trained to install the products of the manufacturer of the automation and control equipment. Installer shall have previous experience installing and programming BACnet system and controllers.
- C. **Project Manager/Engineer's Qualifications:** The qualifications of the EMCS Contractor's proposed project manager/engineer shall be submitted in writing within the time frame of the submittals. The EMCS Contractor's engineer shall have a minimum of five (5) year's experience in the automation and control field with the same company furnishing the work, as well as having been involved in the design and construction of three (3) projects of similar size and scope. The Owner reserves the right to approve the proposed project engineer from the control contractor's staff. The project manager/engineer shall be designated as a key personnel and shall remain assigned to the project through its entire duration of submittals, construction and warranty. The project manager shall be the contractor's and Owner's primary contact.
- D. The EMCS Contractor shall have local emergency service available on a 24 hour, 7 day-a-week basis, with a normal response time from contact to arrival on site of not more than two (2) hours.

1.10 SYSTEM DEMONSTRATION

- A. The Owner reserves the right, at their option, to require a demonstration by a factory authorized representative of the control system prior to acceptance of any temperature control bid.

- B. This demonstration shall occur at the project site and shall include a functional demonstration and complete description of the control system as bid including, but not limited to, a list of representative projects, software routines, hardware components, sequences of operation, programming and troubleshooting techniques, and availability of service and training.

1.11 SEQUENCING AND SCHEDULING

- A. Complete the 96-hour test run (see Part 3 of this section) prior to test and balance.
- B. Pre-balance inspection and adjustment of the control systems shall be performed by the control engineer in the presence of the Engineer. This operation shall be performed prior to the start of the air and water balance work. Pre-balance inspection and adjustment shall include adjustments of all controls and devices as required to prove sequence of operation in all control modes. A written report, signed by participating parties shall be forwarded to the Owner's Representative with a copy enclosed in the O&M manual.
- C. The temperature controls contractor shall assist the balancing agency as required for proper balancing of the systems with assistance as required in Section 230593. Furnish a hand-held controller or laptop service tool for the balance agency use during test and balance. This tool shall be returned to the EMCS Contractor at the end of test and balance.
- D. Final adjustments and calibration of systems and components, including valve and damper operators, shall be accomplished after balancing has been completed and prior to O&M instruction period. This shall include any required setting of controls or labeling of setpoints. The EMCS Contractor shall coordinate scheduling and setpoints with Owner's Representative. A letter of certification, stating the above has been completed and signed by the EMCS Contractor shall be forwarded to the Owner's Representative with a copy enclosed in the O&M manual. The Owner's Representative shall be notified, in writing, two (2) weeks in advance of scheduled time to witness sequence of operation on all systems. All systems shall be fully operational at the time of this demonstration.
- E. See Section 230500 for additional requirements.

1.12 COORDINATION WITH OTHER TRADES

- A. It is the responsibility of the EMCS contractor to communicate all specific needs for proper installation and operation of the EMCS system to all other necessary trades and to verify that those provisions will be made under the terms of this contract without additional cost to the owner.
- B. Coordinate closely with other subcontractors and equipment suppliers to ensure that equipment is provided with features necessary to interface with the EMCS system.
- C. Coordinate and schedule work with all other work in the same area or with work which is dependent upon work by other trades to facilitate mutual progress.
- D. The EMCS Contractor's designated project engineer/manager shall attend the regularly scheduled construction meetings as requested by the General Contractor in response to

current construction activities and shall be familiar with the technical aspects of the EMCS design and capabilities.

1.13 NATIVE BACNET SYSTEM REQUIREMENTS

- A. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, equipment controllers, unitary controllers, and operator devices while re-using the existing controls equipment.
- B. Existing controllers and control components that are removed as part of this project shall be salvaged and CWU shall be provided the option of first right of refusal for spare parts prior to disposal.
- C. The EMCS shall utilize native BACnet architecture as referenced by ANSI/ASHRAE Standard 135-most recent edition.
- D. The communication network between controllers shall be BACnet. All controllers shall utilize native BACnet architecture and shall be independently tested and listed through BACnet Testing Laboratories. See <http://www.bacnetassociation.org/btl>.
- E. All points need to be configured so that a "future" BACnet vendor can read/write to all points from a central Owner Work Station for such tasks that would include, but not be limited to, changing setpoints, making adjustments and scheduling of equipment.

1.14 SYSTEMS AND EQUIPMENT INTERFACES

- A. General: Provide interfaces/integration with these microprocessor-based systems and packaged equipment as indicated on the control drawings. Coordinate closely with the respective subcontractors and their equipment suppliers to ensure that the necessary interface is provided with each piece of equipment.

1.15 COMMISSIONING REQUIREMENT

- A. See Section 230500 for commissioning requirements related to this section of work.
- B. Pre-Functional Performance Testing (FPT) inspection and adjustment of the control systems shall be performed by the control engineer in the presence of the Engineer. This operation shall be performed prior to the start of air and/or water balance work, and/or the actual Functional Performance Testing
- C. The Controls Contractor shall demonstrate operation of control functions for each system as required for Functional Performance Testing. Deficiencies in control functions found during the demonstration shall be corrected and re-demonstrated.
- D. Control contractor shall be available during system balancing and Functional Performance Testing of control systems and manipulate the system as required to perform those tests at the control point settings as specified by the A/E and performed by the Contractor.

- E. Final adjustments and calibration of systems and components including valve and damper operators shall be accomplished after balancing has been completed and prior to the O&M instruction period. This shall include any required setting of controls or labeling of equipment. The Contractor shall coordinate scheduling and set points with Owner. The Owner shall be notified seventy-two (72) hours in advance of the scheduled time to witness the sequence of operation on all systems. All systems shall be fully operational at the time of this demonstration.

1.16 WATER TREATMENT SUPPORT

- A. See Section 232500 for water treatment support requirements related to this section of work.

1.17 ENERGY CODE COMPLIANCE

- A. The EMCS shall comply with all requirements of the current (2021) Washington State Energy Code.

PART 2 - PRODUCTS

2.1 ENERGY MANAGEMENT AND CONTROL SYSTEM (EMCS)

- A. Manufacturers (Refer to Section 230500):
 - 1. Alerton Compass as installed by ATS Seattle Branch Office, no substitutions
- B. Operator's Terminal
 - 1. Operators terminal is existing in a central campus location. Upgrade hardware and software as required to suit this project and software updates.
- C. EMCS Software
 - 1. General
 - a. The EMCS contractor shall provide all software required for efficient operation of the EMCS system. Software shall be modular in design to provide maximum flexibility, expansion, and future revision of the system. All functionality described herein shall be regarded as a minimum.
 - b. The Owner shall be furnished with an unlimited site software license so that they may install an unlimited amount of software on their computers to run and operate the building. At the end of the one (1) year warranty, the Owner shall be provided with software upgrade to match the current version offered by the control manufacturer at no additional charge.
 - c. 32-bit software application compatible with the specified operating system; multi-tasking type environment that allows the user to run several applications simultaneously.

2. Control Algorithms: The system shall have the ability to perform the following pre-tested control algorithms: Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control, and automatic tuning of control loops.
3. Operator Access: Different security levels shall be assignable to each operator. Each command and event shall be capable of being assigned a security level. Access to commands, acknowledgment of alarms, etc. shall be limited in accordance with the operator's security level designation.
4. Password Protection: Multiple operator-specific password access protection shall be provided to allow the user/manager to limit workstation control.
5. Event Reporting: The operator shall have the capability to define which actions get reported in which manners, both individually and globally through grouping of events (initially, a minimum of three (3) reporting groups shall be designated: urgent alarms, general alarms, and general messages). Reported events shall include a time and date stamp, site location and network address, and alpha-numeric event ID. Any one or combination of the following event reporting actions shall be assignable to each event: ASCII file, numeric pager (pages personnel by sending numeric messages to personal pagers through the use of a third-party service), printer, and operator's terminal.
6. Trending: Any point, physical or calculated, shall be capable of trending. Collection of data shall be definable by either pre-defined time intervals or pre-defined changes of value. Trending information from anywhere in the system shall be available at the operator's terminal without requiring intervention by an operator.
7. Scheduling: The system shall be capable of scheduling by zone, individual equipment, groups of zones or equipment, building area, and systems. Equipment or zone groups shall be definable by the operator. Weekly schedules shall incorporate seven (7) independent daily programs. System shall also incorporate one-time and annual event scheduling. The system shall automatically update for daylight savings time and leap years. Schedules shall be capable of being overridden at the operator's terminal.
8. Optimum Start/Stop: Start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable.
9. Source Temperature Optimization: Automatically perform source temperature optimization for all equipment noted to have temperature setpoints reset by system demand in the control diagrams. Capability shall include resetting of temperature setpoints in accordance with user-adjustable parameters as well as starting and stopping of primary mechanical equipment based on zone occupancy and/or zone load conditions. Temperature optimization loops shall be tuned to minimize cycling and maximize system stability.
10. Demand Limiting: The system shall be capable of measuring electrical usage from multiple meters serving one building. Each piece of equipment being controlled shall be programmable to respond to peak demand information. The demand control function shall utilize a sliding window method with the operator being able to establish the kilowatt threshold for a minimum of three (3) adjustable demand levels. The operator shall have the capability to set the individual equipment temperature setpoints for each operator defined demand level. Equipment shall not be shed if these reset setpoints are not satisfied. The system shall have failed meter protection, generating an alarm upon loss of KW signal. System shall archive demand and usage information. Information shall be retrievable by day, month-to-date and year-to-date basis.

11. Night Setback: The system shall allow the space temperature to drift down or up within an adjustable unoccupied temperature range. Heating and/or cooling shall be controlled to maintain the night setback range during the scheduled night setback periods.
12. Timed Local Override: When provided with occupant override capabilities the system shall permit the override of equipment which has been scheduled off. Override history shall be maintained for each timed local override input point. Local override shall allow system operation for up to 2 hours.
13. Economizer: The system shall be capable of switchover from mechanical cooling to economizer cooling based on outside air temperature. Economizer operation shall be capable of being overridden by the operator.

D. Graphical User Interface

1. Floor Plan and System Selection/Penetration: The operator interface shall allow users to access the various system schematics and floor plans via both a graphical penetration scheme and menu selection.
 - a. Graphical penetration scheme: Multiple floor plan displays, when required, shall all be accessible from a single initial screen. System schematics shall be directly accessible from the floor plan display for the area they serve. For zoned systems, both the zone and main system schematics shall be accessible from the floor plan display. For systems that interact with secondary systems and/or equipment (e.g. an air handling unit with a hot water coil served by a heating water system), the secondary system and/or equipment shall be accessible from the primary system schematic. It is the intent of this graphical penetration scheme that, from a single screen, any location served by the system can be accessed and, from any floor plan display, all systems and/or equipment serving that area can be accessed.
 - b. Menu selection: A menu selection shall also be available to the operator, similar in nature and layout to the graphical penetration scheme described above.
2. Floor Plan Displays: Provide color graphic floor plan displays designating each temperature control zone. Each zone shall have a graphic and color-coded indication of space temperature relative to setpoint, with a minimum of five (5) different indicators (e.g. dark blue, light blue, green, yellow, red).
3. System Schematic Displays: Provide color graphic system schematics for all mechanical equipment and systems. Schematics shall be similar in nature to the control diagrams included in the drawings. Each system and/or equipment schematic shall include the following minimum information:
 - a. System designation
 - b. Graphic representation and labeling of all major equipment and components (all scheduled equipment as a minimum)
 - c. Current status of all I/O points applicable to the system (located appropriately for ease of proper association)
4. System Setpoint and Scheduling Adjustments: All system setpoints and schedules shall be adjustable through the graphic interface. This includes all space temperature setpoints, occupied/unoccupied/warm-up schedules, and all points noted in the control diagrams as adjustable. Adjustments shall require only mouse operation and entering of

new values. Changes shall be automatically transferred to the appropriate control module.

5. **Windowing:** The windowing environment of the operator's terminal shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
6. **Programming Accessibility:** Programming for sequences of operation shall be accessible through the graphical user interface.
7. **Setpoint Accessibility:** Each setpoint and/or item indicated in the control diagrams to be adjustable shall be accessible and capable of being modified through the graphical user interface.
8. **Graphics Development Package:** Graphic generation software shall be provided to allow the user to add, modify, or delete system graphic displays.
 - a. The contractor shall provide libraries of pre-engineered screens and symbols depicting standard HVAC components (e.g. fans, cooling coils, filters, dampers, etc.) and electrical symbols.
 - b. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:
 - 1) Define symbols
 - 2) Position and size symbols
 - 3) Define background screens
 - 4) Define connecting lines and curves
 - 5) Locate, orient and size descriptive text, define and display colors for all elements
 - 6) Establish correlation between symbols or text and associated system points or other displays
 - c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout, or any other logical grouping of points which aids the operator in the analysis of the facility. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC panels, including application specific controllers used for DDC unitary or VAV terminal unit control.

E. **Web Browser Interface**

1. **Compatibility:** The system shall be capable of supporting an unlimited number of clients using Internet Explorer. Web browser software shall be compatible with the operating system and system configuration provided.
2. **Consistency with GUI:** Graphical screens developed for the GUI shall be the same screens used for the web browser client. Any animated graphical objects supported by the GUI shall be supported by the web browser interface. The browser shall provide the same view of the system as the graphical user interface including graphics, schedules, calendars, logs, etc. and shall provide the same interface methodology as the GUI. Systems that require different views or that require different means of interacting with objects such as schedules or logs will not be permitted.

3. Security: User identification and password security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented. Limitations of user access and control similar to that provided at the operator's terminal shall be assignable to each user.
4. Editing Capabilities: HTML editing by the operator shall be allowed, but not be required for proper operation.
5. Graphics Storage: Graphical screens shall be stored in the server. Systems that require graphics storage on the client machine are not acceptable.
6. Real-Time Data Displays: Values displayed on the web page shall update automatically without requiring a manual refresh of the web page.
7. Links: Graphical screens on the web browser client shall support hypertext links to other locations on the Internet or on Intranet sites through the Uniform Resource Locator (URL).

2.2 DAMPER AND VALVE ACTUATORS

- A. Manufacturers (Refer to Section 230500):
 1. Belimo, for air handling unit dampers and other system control dampers.
 2. As manufactured by approved EMCS manufacturer, for control valves and air terminal unit dampers. Manufacturers who do not have valves and air terminal unit dampers labeled under the Manufacturer's name shall provide Belimo actuators.
- B. High resolution type with positive feedback on valve or damper position, direct coupled type.
 1. Spring-return operation to fail open or closed upon loss of signal or power when indicated on the drawings as normally open (NO) or normally closed (NC), respectively; constructed to maintain last position upon power failure when not specified to be either normally open or normally closed on the drawings.
 2. Built-in overload protection to prevent damage to the actuator when the actuator or damper reaches its end position.
 3. Designed for a minimum life of 60,000 cycles; selected for compatibility with associated equipment.
 4. Damper actuators sized for 50 % safety factor with ample capacity to hold device at an intermediate position.
 5. Valve actuators sized for torque required for valve close-off at maximum pump differential pressure. Valve actuators shall be factory installed on the valves with necessary hold off brackets and shields to protect the actuator from condensation and over-heating.
 6. Actuator unit shall be submerged in oil and sealed in die cast case; UL listed; 3 year unlimited warranty.
- C. Signals
 1. All actuators shall utilize analog actuators.

2.3 WATER FLOW METER – BTU METER

- A. Manufacturers (Refer to Section 230500):
 - 1. Onicon
- B. Insertion type electromagnetic flow meter are preferred for insertion and removal without system shutdown. On new meter installations where the meter location cannot be isolated, provide “hot tap” installation hardware, otherwise use the standard installation hardware on dry new pipes.
 - 1. F3500 meters where adequate straight pipe exists, approximately 10 pipe diameters upstream and 5 pipe diameters downstream. Accuracy shall be within $\pm 1\%$ of rate from 2-20 ft/s. Overall turndown shall exceed 100:1. Output signals shall be completely isolated and shall consist of the following: (1) analog output; 4-20mA, 0-10V, or 0-5V jumper selectable, (1) scalable dry contact output for totalization, and (1) high resolution frequency output for use with peripheral devices. For installations in non-metallic pipe use grounding rings or probes. Rated for use in domestic water system where applicable.
 - 2. FT3100 inline meters are to be used where inadequate straight pipe exists for specified insertion meter accuracy. Connections to the piping shall be ANSI class 150 flanges. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene or ebonite for low temperature service, PTFE for hot water service. Rated for use in domestic water system where applicable. Each flow meter shall be individually wet-calibrated and accurate to within $\pm 0.4\%$ of reading from 1.6 to 33 feet per second velocity. A certificate of calibration shall be provided with each flow meter. Output signals shall be 4-20 mA and programmable pulse. For installations in non-metallic pipe, install grounding rings between flanges.
 - 3. F4600 inline meters for pipe sizes smaller than 1.25” and smaller. Outputs shall be 4-20ma, pulse, and BACnet if available. Meter includes push-button display interface and NPT fittings. Rated for use in domestic water system where applicable.
- C. Pipe size and flow rate as indicated on the drawings.
- D. Materials-Chilled Water:
 - 1. 316 SS for non-metallic Pipe
- E. Performance and Options
 - 1. Wetted parts shall be bright tin plated brass or Type 316 stainless steel.
 - 2. Sensing method shall be impedance sensing, nonmagnetic and nonphotoelectric.
 - 3. Accuracy $\pm 2\%$ of actual reading from 0.4 to 20 FPS.
 - 4. 400 psi (maximum operating pressure).
 - 5. 200 degrees F (maximum continuous liquid temperature).
 - 6. Non-isolated analog output signals, 0 to 10 VDC and 20 mA, linear with flow. Binary (digital) dry contact output for bi-directional flow meter.
 - 7. 24 VDC power supply.
 - 8. Hot tap installation to include branch outlet tapping, close nipple, full port ball valve and hot tap adapter.

9. Local display shall be LCD with BACnet interface. Display to suit application:
 - a. BTU applications: System 10 (LCD display that displays energy, flow and temperature data)
 - b. Flow applications: Series D-1200 or BD-1200 (bi directional flow)
10. Provide with temperature sensors for monitor of energy in addition to flow when indicated on control drawings.

2.4 CONTROL VALVES

- A. Manufacturers (Refer to Section 230500):
 1. As manufactured by approved EMCS manufacturer, or approved by the Owner's Representative.
- B. 2-way or 3-way as indicated on the drawings
- C. Ball or butterfly valves of suitable construction for intended application in accordance with the manufacturers recommendations
- D. Throttling plugs and renewable composition seats
- E. Stainless steel ball and stems
- F. Suitable for close-off pressure differential equal to the total head of the respective circulating pump or system steam pressure
- G. Provided with manual positioning capability to allow manual positioning of valve in absence of control power
- H. Sized by the control contractor for a 4 psi maximum pressure drop
- I. Pressure rating: 125 PSI minimum working pressure.

2.5 CONTROLLERS

- A. Manufacturers (Refer to Section 230500):
 1. As manufactured by approved EMCS manufacturer.
 2. Equipment Controllers
 - a. Stand-Alone Operation: Integral processor, software, hardware, firmware, and memory sufficient to perform complete stand-alone control and operation of associated equipment.
 - b. Expansion: Controllers shall accommodate multiple I/O expansion modules for the possibility of future expansion.
 - c. Operator's Terminal Interface: All point data, algorithms and application software within a controller shall be custom programmable from the operator's terminal.

- d. Self-Diagnostics: Each controller shall include self-diagnostics, which allow the controller to automatically notify the network controller of any malfunctions or alarm conditions that exceed desired parameters.
- e. Operator's Interface: Each controller shall contain a port for connection of a portable computer. The entire system shall be accessible from this port.

3. Unitary Controllers

- a. Stand-Alone Operation: Upon loss of communication, each unitary controller shall execute its assigned control algorithm in a stand-alone mode.
- b. Zone Temperature Sensor Compatibility: Unitary controllers shall support various types of zone temperature sensors including temperature sensor only, temperature sensor with setpoint adjustment, temperature sensor with local override switch, and temperature sensor with setpoint adjustment and local override switch.
- c. For applications that require airflow measurement, the unitary controller shall include a precision built-in differential pressure transducer. The differential pressure transducer shall have a measurement range of 0 to 4,000 FPM and measurement accuracy of $\pm 5\%$ at 400 to 4,000 FPM. Controller shall include provisions for manual and automatic calibration of the differential pressure transducer. Automatic calibration shall occur whenever the system mode switches from occupied to unoccupied mode or vice versa.
- d. VAV Applications: Unitary controller shall be provided with either a separate or integral direct-coupled electronic actuator. The actuator shall be of the on-off floating point control. The actuator assembly shall mount directly to the damper operating shaft. The actuator shall be electronically protected against overload.
 - 1) Provide serviceable air filter in tubing to VAV controller for airflow sensing technology that uses a flow through device that exposes instrumentation to room air.
- e. Serviceability: Controller wiring terminal bars shall be of detachable type allowing quick serviceability of the electronic controller hardware without removal of the existing wiring.

2.6 TEMPERATURE CONTROL DAMPERS

A. Manufacturers (Refer to Section 230500):

- 1. Air Balance
- 2. American Warming
- 3. Ruskin
- 4. Delta Control Products – Class I
- 5. Tamco

B. Class 1-Low Leak, Galvanized, Air Foil

- 1. Basis of Design: Ruskin CD-60

2. General: Low-leak, airfoil design; galvanized; parallel blade for return air applications and opposed blade for outside and exhaust air applications or as indicated on the drawings.
3. Application:
 - a. Dampers installed in walls or roofs that are not ducted to a fan.
 - b. Dampers used for outdoor air, exhaust, relief and return openings used in airside economizer operation and stairway and shaft vents shall be provided with Class 1A low leak dampers.
4. Construction
 - a. Galvanized steel, 16 gage hat channel frame.
 - b. Galvanized steel, 14 gage airfoil blades, single piece.
 - c. Extruded vinyl double edge blade seals, easily replaceable; self-lubricating stainless steel sleeve bearings.
 - d. Square or hexagonal axles for positive locking (round is not acceptable). Plated steel.
 - e. Linkage concealed in frame.
5. Leakage: AMCA certified for leakage. Maximum leakage for dampers between 12 and 60" wide shall be no greater than 4 cfm per square foot at 1" wg. .

2.7 VARIABLE FREQUENCY DRIVES (VFD'S)

- A. Furnished by the EMCS Contractor in Section 230923 in accordance with Section 230995.

2.8 GENERAL COMPONENTS

- A. Conduit: Conduit shall meet all requirements of the Latest Edition of the National Electrical Code and State Codes and Division 26.
- B. Contactors
 1. Single coil, electrically operated, mechanically held type
 2. Positive locking obtained without the use of hooks, latches or semi-permanent magnets
 3. Doubled break silver to silver type protected by arching contact where necessary
 4. Number and rating of contacts selected for the intended application
 5. Operating and release times shall be 100 milliseconds or less
 6. Equipped with coil transient suppression devices to limit transients to 150 % of rated coil voltage
- C. Electronic Transmitters: Temperature sensing elements shall be thermistor or platinum RTD type as indicated below.
- D. Enclosures: Enclosures shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. Enclosures may

be NEMA 1 when located in a clean dry indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean dry environment. Equipment installed outdoors shall be housed in a NEMA 4 enclosure. Penetrations shall be sealed to preclude entry of water using a silicone material. All control panels shall be UL listed for code compliance.

- E. Nameplates: Provide laminated plastic nameplates for all equipment and monitoring and control devices in accordance with the requirements of Section 230553. Each nameplate shall identify the function, such as "mixed air controller" or "cold deck temperature sensor". Nameplates shall be in accordance with the requirements of Section 230553.

- F. Power Conditioning
 - 1. Capacity shall match the equipment served
 - 2. Output 120 VAC, +6 to -8 % at 90 to 136 VAC input
 - 3. Maximum 2 % total harmonic wave form distortion
 - 4. 10 million to 1 common-mode noise attenuation (140dB minimum at 0.0)
 - 5. 57dB normal-mode noise attenuation for 10 Hz to 1 MHz
 - 6. Provide for all solid state equipment unless protection meeting these requirements is an integral part of the equipment.

- G. Relays
 - 1. General:
 - a. Rated for the intended application
 - b. Minimum of 2 sets of Form C contacts
 - c. Enclosed in a dust-proof enclosure
 - d. Rated for a minimum life-cycle of 1,000,000 operations
 - e. 20 milliseconds or less operating time
 - f. 10 milliseconds or less release time
 - g. Equipped with coil transient suppression devices to limit transients to 150 % of rated coil voltage
 - 2. Enclosed Relays (Relay-in-a-Box) RIB: SPDT enclosed relays with nipple mount for panel applications with LED status pilot light.
 - 3. DIN Socket Control Relays:
 - a. Plug-in type with dust cover
 - b. Contact rating, configuration, and coil voltage suitable for application
 - c. UL listed
 - 4. Time Delay Relays:
 - a. Solid state plug-in type with adjustable time delay
 - b. Delay shall be adjustable plus or minus 200 % from setpoint called for
 - c. Contact rating, configuration, and coil voltage suitable for application
 - d. NEMA 1 enclosure when not installed in local control panel

- H. Sensors

1. General: Sensors and control elements shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.
2. Provide wall boxes for sensing elements for conduit rough-in with extension rings if required due to finished surfaces on the walls.
3. Duct Temperature Sensors: Resistor Temperature Detector (RTD) with platinum element and transmitter to match resistance range of RTD or thermistor type, accuracy of 0.1 % at 32 degrees F.
 - a. Use averaging type on mixed air plenums and downstream from heating and cooling coils. Averaging type sensor encased in bendable copper sheath of the length required (normally 24 feet long). Serpentine element horizontally.
 - b. Use direct insertion probe type on return air and supply air ducts. Use 4 inch long probe on terminal box discharge supply ducts. Use 12 inch long probe on main return air and supply air ducts.
4. Low Limit Thermostats (Freezestats): Dual signal low temperature cut-out and alarm thermostat with remote sensing element. Manual reset type selected for the application. Bulb shall be approximately 20 feet long for use in large ducts or plenums and shall be designed to stop the respective fan should the temperature drop below setpoint along any one foot length of the bulb. 15 to 55 degrees F adjustable range.
 - a. Provide with two sets of contacts. One to hardwire to equipment for shutdown and one for the DDC system for monitoring.
5. Outside Air Temperature Sensors: Resistor Temperature Detector (RTD) or thermistor; -20 °F to 180 °F temperature range, sun shield and weatherproof assembly for mounting to rigid conduit.
 - a. Install away from exhaust/relief vents. Preference should be given to locate as near as possible to the outside air intake for the air handling equipment, but keeping it out of direct sunlight or other reflective sources that would adversely affect its accuracy. When possible the sensor should be located on the northwest outside building wall.
6. Room Temperature Sensors:
 - a. 10K ohm at 77 degrees F thermistor, ± 0.5 degrees F accuracy.
 - b. Provide with integral communications jack to communicate with the zone's unitary controller.
 - c. The contractor shall review with the Owner prior to the submittal of shop drawings the specific sensor types and features. For the purposes of the bid, sensors shall be provided as follows:
 - 1) Sensors in occupied areas:
 - a) LCD display with space temperature and set-points
 - b) Set point adjustment buttons or slider
 - c) Local occupancy over-ride

- d) Where RH sensors are indicated on plans, provide with integral RH sensing (10% to 90%): +/- 1.8% typical. Less than 0.5% drifter per year.
 - e) Where CO2 sensors are indicated on plans, provide with integral CO2 sensing (400 to 1250 ppm: +/- 30 ppm or 3% of reading whichever is greater) (1250 to 2000 ppm: +/- 5% of reading)
- 2) Sensors in non-regularly occupied areas shall have blank tamperproof covers with no display, no adjustment and no over-ride. Areas that are not regularly occupied consist of:
- a) Mechanical, electrical, telecom and elevator machine rooms
 - b) Storage rooms, custodial rooms, restrooms
 - c) Lobbies without reception desk
 - d) Halls
 - e) Egress stairs

7. Immersion Temperature Sensors:

- a. 10K ohm at 77 degrees F thermistor, ± 0.5 degrees F accuracy.
- b. Range as suitable for application.
- c. Provide stainless steel or brass thermowell for threaded mounting into pipe.
- d. Thermal paste shall be used in all thermowells.
- e. 4 or 8 inch insertion length depending upon pipe size and mounting configuration available (elbow, lateral or straight).

8. Pressure Sensors:

- a. Air Differential Pressure Sensors:
 - 1) Electronic transducer
 - 2) Linear variable differential transformer type sensing element with two-wire transmitter
 - 3) 2 % of full scale accuracy
- b. Liquid Differential Pressure Sensors:
 - 1) Single pole, single throw switch
 - 2) Bellows type
 - 3) Adjustable range
 - 4) Suitable for intended application
 - 5) Pressure and Temperature Test Ports
 - 6) Equal to 5-Valve Manifold by Setra to allow for isolation, calibration and troubleshooting

I. Switches

1. Air Flow Switches:

- a. General purpose utilizing differential air pressure.

- b. SPDT snap-acting contracts.
 - c. Adjustable from 0.1 to 2.0 inches WG minimum or as required for the intended application.
 - d. Aluminum construction with neoprene diaphragm.
2. Bypass Switches:
- a. Momentary contact type push button.
 - b. Installed in standard wall box with stainless steel cover.
3. Current Switches (fan and pump status):
- a. Self-powered.
 - b. Solid state.
 - c. Adjustable trip current; selected to match the current of the application and output requirements of the EMCS system.
 - d. UL listed.
 - e. Provide variable frequency drive rated current switches on motors with VFDs.
4. Damper End Switches:
- a. Momentary type limit switches for monitoring motion of the damper at a prescribed arc of rotation.
 - b. Hermetically sealed mercury contacts that operate by way of a trip lever.
 - c. Mounted on the exterior of the duct so that the trip lever is aligned with the damper vane.
 - d. Mechanically adjustable in the switch case to set the proper lever action for tripping the mercury switch contacts.
 - e. SPDT contact arrangement exceeding the load requirements for both voltage and current.
5. Air Differential Pressure Switches:
- a. Snap-acting
 - b. Pilot duty rated (125 VA minimum)
 - c. NEMA 1 enclosure
 - d. Scale range and differential suitable for intended application
 - e. UL listed
 - f. Filter Status: Range 0.05 to 2.0 inches WG, adjustable, SPDT contacts, 15 amps at 277 VAC.
 - g. Duct High Limit: Range 0.40 to 12.0 inches WG adjustable, SPST contacts, 15 amps at 277 VAC, manual reset.
6. Flow Switches:
- a. Air Service:
 - 1) Differential pressure type switches as specified above.
 - b. Water Service:

- 1) Paddle type switch.
 - 2) Snap-acting with pilot duty rating (125 VA minimum).
 - 3) Adjustable sensitivity.
 - 4) NEMA 1 enclosure.
 - 5) UL listed.
 - 6) Alternatively, differential pressure type switches as specified herein.
7. On/Off Switch:
- a. Standard wall box type switch.
 - b. Single pole.
 - c. Illuminated switch with light activated when controlled device is on.
 - d. Stainless steel cover plate.
8. Pressure-Electric Switches:
- a. Metal or neoprene diaphragm actuated.
 - b. 1- or 2-stage switch action as required by application.
 - c. Open type when panel-mounted or enclosed type for remote installation.
 - d. Enclosed type shall be in a NEMA 1 enclosure unless noted otherwise.
9. Water Differential Pressure Switches:
- a. General purpose liquid flow switch.
 - b. SPDT snap-acting contacts.
 - c. Adjustable; neoprene diaphragm.
 - d. Dust-tight enclosure.
 - e. 150 PSIG maximum operating pressure.
 - f. 250 degrees F maximum operating temperature.
- J. Sensor Wells
1. Bronze or brass with NPT threads sized to match associated device.
- K. Transformers
1. Current Transformers:
 - a. Current ratio as necessary for application.
 - b. Windings completely enclosed, except for terminals.
 - c. 1 % of full scale accuracy.
 - d. UL listed.
 2. Voltage Transformers:
 - a. 600 VAC rated.
 - b. Complete with built-in fuse protection.
 - c. Windings completely enclosed, except for terminals.
 - d. Suitable for ambient temperatures of 40 to 130 degrees F.
 - e. 0.5 % accuracy at 24 VAC.

- L. Transmitters
 - 1. Current Transmitters:
 - a. Self-powered combination split-core current transformer type with built-in rectifier and high-gain servo amplifier.
 - b. Unit range as necessary for application.
 - c. Internal zero and span adjustment.
 - d. 1 % of full scale accuracy.
 - e. UL listed.
 - 2. Voltage Transmitters:
 - a. Self-powered single loop type.
 - b. Internal zero and span adjustment.
 - c. 1 % of full scale accuracy.
 - d. UL listed.
- M. Wiring: All wiring shall be compliant to local building codes and the NEC and Division 26 of these specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.
- C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the Contractor's work and the plans and the work of others, the Contractor shall report these discrepancies to the Engineer and shall obtain written instructions for any changes necessary to accommodate the Contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by this contractor at his expense.
- D. Review shop drawings for equipment being monitored by the EMCS system in the project submittal stage to ensure that equipment arrives with the proper control interface and communications protocol. Provide control integration drawings as previous indicated in part 1 submittal requirements of this section.

3.2 GENERAL

- A. Installation of temperature control system and equipment shall be complete under this section. Provide all required system components and wiring necessary to accomplish the specified sequences of operation as indicated on the drawings.
 - 1. Exception: Components specified to be factory furnished with a particular mechanical equipment item.
- B. All control devices installed in ductwork shall be positively anchored and attached to the ductwork by mechanical means. Duct access panels shall be provided for all such devices.
- C. It shall be the responsibility of this contractor to provide power for all devices requiring power. Coordinate with other trades to arrange for necessary power circuits. All control devices shall obtain power from dedicated control circuits. Provide control voltage transformers for low voltage control power.
- D. Wiring as used herein shall be construed as all wiring, conduits, hangers, etc., required for successful operation of the system. All wiring shall be in strict accordance with the latest edition of the National Electrical Code and local and state electrical code requirements and Division 26.
- E. Install equipment, piping, and wiring/raceways parallel to building lines wherever possible.
- F. All control wiring diagrams shall be laminated and adhered to the inside of control enclosures.

3.3 MOTOR CONTROLS

- A. Variable Frequency Drives (VFD's)
 - 1. VFD's furnished in Section 230923 shall be installed in accordance with the requirements of Section 230995.
 - 2. When VFD's are provided by others or as an integral part of the equipment, the control contractor shall attend the field start up and testing of the drives that are provided by others.
- B. For single phase motors, provide a 20 amp control relay in a box for EMCS start and stop in the power wiring circuit provided by Division 26.
- C. For three phase motors not furnished with VFD's, unless indicated otherwise, Division 26 provides a 120 volt control voltage transformer and contactor. Control contractors shall provide a 20 amp control relay in a box to intercept the control circuit.
- D. Coordinate locations of control relays and installation of work with Division 26.
- E. Safety relays for equipment shutdown are provided by Section 230923. This includes high static, freeze stat, etc are furnished and installed by Section 230923.

- F. Relays for shutdown for fire alarm conditions are provided by Division 28.

3.4 INSTALLATION

- A. Actuators: All actuators for dampers furnished with air handling units shall be furnished under this Section 230923, and in accordance with the control drawings, and field installed in accordance with the air handling unit manufacturer's requirements. Section 230923 Contractor shall coordinate with the various air handling unit manufacturers as to the size and quantity of actuators required for proper control of the dampers.
- B. Control Valves: Valves furnished under this section shall be installed under the Section associated with the piping system in which the valve is being installed. Coordinate with the appropriate piping contractor.
- C. Controllers
 - 1. General: Controllers shall be installed in convenient locations directly on or immediately adjacent to the controlled equipment. If locations are not shown on the drawings, verify location with owner's representative prior to installation.
 - 2. Equipment Controllers: Provide a dedicated controller for each air handling unit or other HVAC system.
 - a. Exception: A single controller can serve multiple air handling units or systems if all points for each individual system are connected to the same system and required spare capacities are maintained as noted below. Points for a single system connected to multiple panels are unacceptable.
 - b. Spare Capacity: Provide a minimum of one AI/AO/DI and DO spare point at each air handler, boiler, and chiller controller. Provide a minimum of 25 % spare capacity on each communication trunk for future use.
- D. General Components
 - 1. Conduit: Provide as required in the wiring section in complete accordance with the applicable version of the NEC. Conduit terminations shall be free from burrs with a strain relief fitting provided.
 - 2. Nameplates: Provide system and component labeling in accordance with the requirements of Section 230553. All control components, including all enclosures, except room temperature sensors shall be equipped with nameplates to identify each control component. Contractor shall submit proposed labeling list prior to installation of labels.
 - 3. Sensors
 - a. General:
 - 1) Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - 2) All wires attached to sensors shall be air-sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

- 3) Duct Temperature Sensors: Averaging type sensors installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
 - 4) Low Limit Thermostats: Installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Locate on the inlet side of air handling unit cooling coils close the outside air damper.
 - 5) Outside Air Temperature Sensors: Install on a north wall complete with sun shield. Verify location with the Engineer prior to installation.
 - 6) Pressure Sensors: The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 7) Room Temperature Sensors: Install on concealed junction boxes properly supported by the wall framing.
4. Thermometer Wells: All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
 5. Transmitters
 - a. Provide for all temperature and pressure sensing
 - b. Serpentine transmitter and controller cap tube averaging elements in mixed air and across coil face to prevent possibility of sensing stratified air
 - c. Provide access panels for temperature transmitters located in return/exhaust ductwork
 6. Wiring
 - a. Wiring inside control cabinets shall be dressed neatly and tied with Thomas and Betts wire ties. Plastic tooth wire ties are not acceptable.
 - b. All field wiring entering control cabinets shall be labeled with Thomas and Betts self-laminating wire markers or appropriate alphanumeric labels corresponding to termination shown on the control drawings. Colored phase tape shall not be used.
 - c. Wiring routed from equipment shall be in a manner as to avoid injury to the wiring.
 - d. "Across-the hinge" wiring shall be dressed to avoid strain and abrasion. Provide spiral wrap suitable to this application.
 - e. Install instrumentation grounding as necessary to preclude ground loops and noise from adversely affecting equipment operations.
 - f. Wiring shall be enclosed in conduit in the following conditions:
 - 1) All wiring in mechanical/equipment rooms.
 - 2) Concealed wiring.
 - 3) Outdoor wiring.
 - 4) Direct buried wiring. Direct bury shall also include locate tape above conduit and shall be installed in accordance with the requirements of the NEC.
 - 5) Wiring mounted on vibrating equipment such as fans and compressors. (Avoid crossing flexible connections or vibration isolation components. Where wiring leaves vibrating equipment, provide ample flexible conduit to permit normal machinery movement.)

- 6) Wiring routed above ceilings.
- 7) All wiring associated with smoke control system.
- 8) Communication wiring.
- 9) Exception:
 - a) Conduit for wiring above accessible T-bar ceilings may be omitted if approved by local and state electrical code authorities.
 - b) Conduit for wiring in return air plenums may be omitted if approved by local and state electrical code authorities, providing that the contractor utilize plenum rated cable.

g. All wiring requirements noted above apply to communications wiring. The following requirements are intended to be supplemental to those requirements.

- 1) Communication wiring shall not be installed in raceway and enclosures containing Class 1 or other Class 2 wiring.
- 2) Maximum pulling, tension, and bend radius for cable installation as specified by the cable manufacturer shall not be exceeded during installation.
- 3) Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.
- 4) Provide a lightning arrestor between the lines and ground wherever a cable enters or exits a building.
- 5) Communication wiring shall be installed in continuous lengths. Spliced wires are not acceptable.
- 6) Grounding of coaxial cable shall be in accordance with NEC Regulations Article on Communications Circuits, Cable and Protector Grounding.

7. Fiber Optic Cabling

- a. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.
- b. All cabling and associated components shall be installed in accordance with manufacturer's instructions. Minimum cable unjacketed fiber bend radii as specified by cable manufacturer shall be maintained.

E. Labeling

1. All controls junction boxes shall be painted yellow. Control conduit must be tagged with at least four-inch-long yellow labels at maximum 20-foot intervals. A minimum of one label per room shall be required.
2. Provide labeling in accordance with the requirements of Section 230553.

3.5 START-UP, CALIBRATION, TESTING AND DEMONSTRATION

A. Start-up and check-out

1. Verify that all circuits, controls and devices are properly installed.

2. Check connectivity of all control points between field devices and controllers. Check and confirm all device addresses and control points.
 3. Verify that all dampers and control valves operate in the correct direction.
 4. Energize the controlled equipment and test for proper operation. Make all necessary adjustments, remove and replace any malfunctioning devices and retest.
- B. Calibration and Adjusting
1. Calibrate all sensors and devices.
 2. Submit calibration sheets to the Owner's Representative.
 3. Make 3-point calibration test for both linearity and accuracy for each analog device.
 4. Calibrate devices according to manufacturer's directions.
 5. Adjust flow, pressure and temperature switches.
 6. Stroke and adjust control valves and dampers.
 7. Adjust all initial temperature setpoints.
- C. Testing
1. The completed control system shall be adjusted and tested under operating conditions by a qualified technician in the employ of the EMCS Contractor.
 2. Before commencing the testing, the technician shall prepare an Owner approved, itemized log for the full range of control functions for each system. The log shall be initialed by the test engineer as each test is performed.
 3. When the testing is completed, the test log and a letter of certification stating that all control functions of the system have been checked and are in satisfactory operating order and in compliance with the contract documents shall be given to the Owner.
- D. Programming
1. Coordinate occupied/unoccupied schedule for each unit and zone with the Owner and provide project specific schedules in the programming. Schedules shall include occupied/unoccupied modes with night setback control.
 2. Coordinate occupied and unoccupied setpoints with the owner and adjust in the program. Provide a minimum of 5 degree deadband between heating and cooling setpoints. Initial settings (unless adjusted by owner) shall be as indicated on the drawings.
 3. Provide staggered start-up of equipment after power outage or at morning warm-up to prevent high amp draw on building electrical service.
 4. Equipment shall return to a failsafe unoccupied mode after emergency shutdown (freeze stat, fire alarm etc) with outside air dampers close and return dampers open.
 5. Provide optimized start on air distribution systems with a supply air capacity exceeding 10,000 cfm served by one or more supply fans. The control algorithm shall, as a minimum, be a function of the difference between the space temperature and occupied setpoint and the amount of time prior to the scheduled occupancy.
 6. Where multiple pieces of equipment serve the same space and have multiple pieces of heating and cooling equipment, controls shall be interlocked through programming to prohibit simultaneous heating and cooling.

7. For energy and flow metering provided on the project, provide trend logs that indicate total monthly flow/energy and peak monthly demand. The extent of devices capable of power monitoring is indicated on the control diagrams. Device may include:
 - a. VFD's: Monitor of fan energy through VFD interface
 - b. Analog Current transducers
 - c. Flow and btuh through btuh/energy meters
 - d. Water flows from water flow meters

E. Operator's Terminal

1. All points of control shall be available at the operators terminal (visual and hard copy printout).
2. Alarms shall register for equipment status or conditions out of setpoint range.

F. Demonstration

1. The complete and fully operational control system shall demonstrated to the designated Owner's personnel and project engineer upon completion of successful start-up and testing. Demonstration shall be an overview of the entire functionality of the system including the operator's terminal, the web browser interface, the graphical user interface, remote control point adjustment, scheduling procedures, overrides, alarms, unitary and terminal unit control.
2. Demonstration of the system shall occur in order to verify overall compliance with the above start-up and testing.
3. Demonstration shall be prior to, and in addition to, the required operator training.

3.6 SERVICE AND TROUBLE SHOOTING

- A. Perform the regularly scheduled maintenance service visits as required by Part 1 of these specifications.
- B. Provide warranty service and system troubleshooting as needed during the project warranty period.

3.7 SYSTEM SCHEDULING

- A. During initial set-up and programming of the control system, the EMCS Contractor shall work closely with the Owner's staff to develop and program equipment utilization schedules.
 1. Equipment utilization schedules shall allow the Owner to operate groups of equipment in occupied mode based on the use of the building through selection of the appropriate utilization schedule at the Operator's workstation. Any piece of equipment shall have the capability of belonging to more than one utilization schedule.
 2. The type and expected duration of the building activities shall dictate which mechanical systems and HVAC equipment must be operational, as well as the appropriate occupied setpoints.

3.8 96-HOUR TEST RUN

- A. The 96-hour test run shall be made when all field equipment is installed and the system is calibrated and running, test and balance is complete, and when all other building systems (including drywall, windows, doors, etc.) are complete. This period is intended to demonstrate the operation of the complete building.
- B. The 96-hour test run shall include performance of all associated software and hardware operations called for in these specifications. The test shall be for a duration of 96 continuous hours with no Contractor maintenance required. The pre-balance conference shall not be scheduled until this test has been completed satisfactorily (i.e. run without errors or alarms for a continuous 96-hour period). Notify Owner's Representative prior to beginning the 96-hour run test.

3.9 COMMISSIONING REQUIREMENTS

- A. Refer to Section 230500, 230800, and Division 1.
- B. Assist with set up of trend logs required by the commissioning agent.

3.10 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

PART 4 - SEQUENCE OF OPERATIONS

4.1 SEE CONTROL DIAGRAMS ON DRAWINGS FOR REQUIRED SEQUENCE OF OPERATION.

END OF SECTION 23 0923

SECTION 23 0995 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Variable Frequency Drives to be furnished by Section 230923 in accordance with this section unless specified or scheduled to be factory furnished with the particular mechanical equipment item.
- B. This specification is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with both asynchronous and permanent magnet motors.
- C. The drive manufacturer shall supply the drive and all necessary options as specified. All drives installed on this project shall be from the same manufacturer and have a common user interface (control panel). Drives that are manufactured by a third party and “brand labeled” shall not be acceptable.

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230513 – Common Motor Requirements for HVAC Equipment
- C. Section 230923 – Direct-Digital Control for HVAC
- D. Section 237300 – Central Station Air Handling Units
- E. Division 26

1.3 SUBMITTALS

- A. Submit in accordance with Section 230500. Submittals shall include the following information:
 - 1. Outline dimensions, conduit entry locations and weights. Customer connection and power wiring diagrams.
 - 2. Seismic certification and installation requirements where applicable.
- B. Complete technical product description with complete list of options provided. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

1.4 STANDARDS AND GUIDELINES

- A. Institute of Electrical and Electronic Engineers (IEEE): IEEE 519-2014
- B. Underwriters Laboratories (as appropriate): UL 508, 508A, 508C, UL 61800, 61800-5-1, 61800-5-2, UL 1995
- C. The Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA): NEMA ICS 7-2014, Adjustable Speed Drives
- D. International Electrotechnical Commission (IEC): EN/IEC 61800
- E. National Electric Code (NEC): NEC 430.120, Adjustable-Speed Drive Systems
- F. CSA Group: CSA C22.2 No. 274
- G. International Building Code (IBC): IBC 2018 Seismic – referencing ASCE 7-16 and ICC AC-156

1.5 QUALITY ASS7URANCE

- A. Drives shall be UL labeled as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR when installed in accordance with the manufacturer's guidelines.
- B. The base drive shall be CE and meet EN 61800-3 for the First Environment restricted distribution (Category C2).
- C. The base drive shall be seismically certified per 2018 International Building Code (IBC) with a seismic importance factor of 1.5, and minimum 2.5 S_{DS} rating.
- D. The base drive shall be SEMI-F47 certified. The drive must tolerate voltage sags to 50% for up to 0.2 seconds, sags to 70% for up to 0.5 seconds, and sags to 80% for up to one second.
- E. Product Support
 - 1. Factory trained support personnel shall be locally available at both the specifying and installation locations. A toll free 24/365 technical support line connected to factory support personnel located in the US and Canada shall be available.
 - 2. Factory training of support personnel shall include installation, programming and operation of the drive, bypass and network communications.
- F. Service
 - 1. Manufacturer shall maintain a service center or service representative within 150 miles of the job site. This center must normally provide the following services:
 - a. Factory coordinated start-up service.
 - b. Perform service calls and providing replacement parts within twenty-four (24) hours.
 - c. Provide service contracts.

- d. Training of customers in operation and basic troubleshooting.
- e. Maintaining a stock of frequently replaceable parts at a local warehouse.

1.6 WARRANTY

- A. Warranty shall be provided for the greater duration of the two following conditions:
 - 1. The drive Product Warranty shall be 30 months from the date of shipment from the factory. The warranty shall include: Parts, on-site labor, and travel time and travel costs, or replacement of the complete drive as determined by the drive manufacturer's technical support.

PART 2 - PRODUCTS

2.1 VARIABLE FREQUENCY DRIVES (FULLY FEATURED)

- A. Manufacturers (refer to Section 230500):
 - 1. ABB, ACH 580 Series
- B. See Section 230549 for seismic design requirements for equipment.
- C. The drive package as specified herein and defined on the drive schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer to ISO9001 standards.
- D. The drive shall provide full rated output from a line of +10% to -15% of nominal voltage. The drive shall continue to operate without faulting from a line of +25% to -35% of nominal voltage.
 - 1. Unless scheduled otherwise on the drawings, drives shall be capable of continuous full load operation under the following environmental operating conditions:
 - a. Ambient temperature -15 to 40° C (5 to 104° F).
 - b. Altitude 0 to 1000 m (0 to 3,300 ft) above sea level.
 - c. Humidity 5 to 95%, non-condensing.
- E. All drives shall utilize the same Advanced Control Panel (keypad) user interface.
 - 1. Plain English text
 - a. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable).
 - b. Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch, smoke alarm, vibration trip, and overpressure.

- c. Safety interlock, run permissive, and external fault status shall have the option of additional customized project specific terms, such as: AHU-1 End Switch, Office Smoke Alarm, CT-2 Vibration.
2. The control panel shall include at minimum the followings controls:
 - a. Four navigation keys (Up, Down, Left, Right) and two soft keys to simplify operation and programming.
 - b. Hand-Off-Auto selections and manual speed control without having to navigate to a parameter.
 - c. Fault Reset and Help keys. The Help key shall include assistance for programming and troubleshooting.
3. Multiple Home View screens shall be capable of displaying up to 21 points of information. Customizable modules shall include bar charts, graphs, meters, and data lists. Displays shall provide real time graphical trending of output power, frequency, and current within selectable intervals of 15/30/60 minutes and 24 hours.
4. The control panel shall display the following items on a single screen; output frequency, output current, reference signal, drive name, time, and operating mode (Hand vs Auto, Run vs Stop). Bi-color (red/green) status LED shall be included. Drive (equipment) name shall be customizable.
5. There shall be a built-in time clock in the control panel. The clock shall have a battery backup with 10 years minimum life span. Daylight savings time shall be selectable.
6. I/O Summary display with a single screen shall indicate and provide:
 - a. The status/values of all analog inputs, analog outputs, digital inputs, and relay outputs. Drives that require access to internal or live components to measure these values, are not acceptable.
 - b. The programmed function of all analog inputs, analog outputs, digital inputs, and relay outputs.
 - c. The ability to force individual digital I/O high or low and individual analog I/O to desired value, for increased personal protection during drive commissioning and troubleshooting. Drives that require access to internal or live components to perform these functions, are not acceptable.
7. The drive shall automatically backup parameters to the control panel. In addition to the automatic backup, the drive shall allow two additional unique backup parameter sets to be stored. Backup files shall include a time and date stamp. In the event of a drive failure, the control panel of the original drive can be installed on the replacement drive, and parameters from that control panel can be downloaded into the replacement drive.
8. The control panel shall display local technical support contact information as part of drive fault status.
9. The control panel shall be removable, capable of remote mounting.
10. The control panel shall have the ability to store screen shots, which are downloadable via USB.
11. The control panel shall have the ability to display a QR code for quick access to drive information.

12. The LCD screen shall be backlit with the ability to adjust the screen brightness and contrast, with inverted contrast mode. A user-selectable timer shall dim the display and save power when not in use.
 13. The control panel shall include assistants specifically designed to facilitate start-up. Assistants shall include: First Start Assistant, Basic Operation, Basic Control, and PID Assistant.
 14. Primary settings for HVAC shall provide quick set-up of all parameters and customer interfaces to reduce programming time.
 15. The drive shall be able to operate with the control panel removed.
 16. The drive shall be able to support a Bluetooth Advanced Control Panel. The Bluetooth control panel shall be FCC and QDL (Qualified Design Listing) certified.
 - a. A free app (iOS and Android) shall replicate the control panel on a mobile device or tablet. The control panel's programming and control functionality shall function on the device. Customizing text, such as AHU-1 End Switch, shall be supported by the device's keyboard.
 - b. Bluetooth connectivity shall allow uploading, downloading, and emailing of parameter sets.
 - c. Bluetooth connectivity shall include two pairing modes: Always discoverable with a fixed passcode, and manual discovery with a unique generated passcode every pairing.
 - d. The Bluetooth antenna shall be in the control panel. Antennas that are integrated in the drive's control board, must include an external antenna, on all drives mounted inside cabinets.
 - e. Bluetooth connectivity shall be capable of being switched off.
- F. All drives shall have the following hardware features/characteristics as standard:
1. Two (2) programmable analog inputs shall accept current or voltage signals. Current or Voltage selection configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
 2. Two (2) programmable analog outputs. At least one of the analog outputs shall be adjustable for current or voltage signal, configured via control panel. Drives that require access to internal components to perform these functions, are not acceptable.
 3. Six (6) programmable digital inputs. All digital inputs shall be programmable to support both active high and active low logic, and shall include adjustable on/off time delays. The digital input shall be capable of accepting both 24 VDC and 24 VAC.
 4. Three (3) programmable Form-C relay outputs. The relay outputs shall include programmable on/off time delays. The relays shall be rated for a continuous current rating of 2 Amps. Maximum switching voltage of 250 VAC / 30 VDC. Open collector and Form-A relays are not acceptable. Drives that have less than (3) Form-C relay outputs shall provide an option card to provide additional relay outputs.
 5. Drive terminal blocks shall be color coded for easy identification of function.
 6. The drive shall include an isolated USB port for interface between the drive and a laptop. A non-isolated USB port is not acceptable.
 7. An auxiliary power supply rated at 24 VDC, 250 mA shall be included.
 8. At a minimum, the drives shall have internal impedance equivalent to 5% to reduce the harmonics to the power line. 5% impedance may be from dual (positive and negative

DC link) chokes, or AC line reactor. Drives with only one DC link choke shall add an AC line choke integral to the drive enclosure.

- a. On select projects, additional harmonic mitigation will be required. Reference the drive schedule to determine if additional harmonic mitigation is required for the system to comply with IEEE 519-2014. Additional harmonic mitigation, if required, will be identified by the project electrical engineer.
9. The drive shall have cooling fans that are designed for field replacement. The primary cooling fan shall operate only when required and be variable speed for increased longevity and lower noise levels. Drives whose primary cooling fans are not variable speed, shall include a spare cooling fan.
 10. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. The minimum current rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.
 11. The input current rating of the drive shall not be greater than the output current rating. Per NFPA 70 430.122, drives with higher input current ratings may require the upstream wiring, protection devices, and source transformers to be upsized.
 12. Circuit boards shall be coated per IEC 60721-3-3; Chemical gasses Class 3C2 and Solid particles Class 3S2.
 13. Earth (ground) fault detection shall function in both modulating (running) and non-modulating modes.
 14. Surge protection device provided in accordance with UL 14449.
 15. Coordinated AC transient surge protection system consisting of 4 MOVs (phase-to-phase and phase-to-ground), a capacitor clamp, and internal chokes. The MOVs shall comply with UL 1449 4th Edition. Drives that do not include coordinated AC transient surge protection shall include an external TVSS/SPD (Transient Voltage Surge Suppressor/Surge Protection Device).
 16. The drive shall include a robust DC bus to provide short term power-loss ride through. The DC bus Joule to drive kVA ratio shall be 4.5 J/kVA or higher. An inertia-based ride through function should help maintain the DC bus voltage during power loss events. Drives with control power ride through only, are not acceptable.
All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the Second Environment restricted level with up to 100 feet of motor cable. No Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, Second Environment.
- G. All drives shall have the following software features as standard:
1. A Fault Logger that stores the last 16 faults in non-volatile memory.
 - a. The most recent 5 faults save at least 9 data points, including but not limited to: Time/date, frequency, DC bus voltage, motor current, DI status, temperature, and status words.
 - b. The date and time of each fault and fault reset attempt shall be stored in the Fault Logger.

2. An Event Logger that stores the last 16 warnings or events that occurred, in non-volatile memory.
 - a. Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, and automatic reset of a fault.
 - b. The date and time of each event's start and completion points shall be stored in the Event Logger.
3. Programmable start method. Start method shall be selectable based on the application: Flying-start, Normal-start, and Brake-on-start.
4. Programmable loss-of-load (broken belt / coupling) indication. Indication shall be selectable as a control panel warning, relay output, or over network communications. This function to include a programmable time delay to eliminate false loss-of-load indications.
5. Motor heating function to prevent condensation build up in the motor. Motor heating adjustment, via parameter, shall be in "Watts." Heating functions based only on "percent current" are not acceptable.
6. Advanced power metering abilities shall be included in the drive. Drives without these data points, must include a separate power meter with each drive.
 - a. Instantaneous output power (kW)
 - b. Total power, broken down by kWh, MWh, and GWh units of measurement. Power meters that only display kWh and roll over or "max out" once the maximum kWh value is reached, are not acceptable. There shall be resettable and non-resettable total power meters within the drive.
 - c. Time based kWh metering for: current hour, previous hour, current day, and previous day.
 - d. Energy saving calculation shall be included that shows the energy and dollars saved by the drive.
7. The drive shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise.
8. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command, the Drives shall provide a dry contact closure that will signal the damper to open. When the damper is fully open, an end-switch shall close, allowing the drive to run the motor.
 - a. The drive shall also include a programmable start delay, for when an end-switch is not provided.
9. Start interlock circuit - Four separate start interlock (safety) inputs shall be provided. When any safety is opened, the motor shall be commanded to stop. The control panel will display the specific safety(s) that are open. The status of each safety shall be transmitted over the network communications. Wiring multiple safeties in series is not acceptable.
10. External fault circuit – Three separate external fault inputs shall be provided. This circuit shall have the same features and functionality as the start interlock circuit, except it shall require a manual reset before the drive is allowed to operate the motor.

11. The drive shall include a switching frequency control circuit that reduces the switching frequency based on actual drive temperature, and allows higher switching frequency settings without derating the drive. It shall be possible to set a minimum and a target switching frequency.
12. Visual function block adaptive programming allowing custom control schemes, minimizing the need for external controllers. i.e. cooling tower staging logic. A free software tool shall be used to configure adaptive programming.
13. The ability to automatically restart after an over-current, over-voltage, under-voltage, external fault, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable. Each of these faults may have automatic restart individually disabled via a parameter selection.
14. Three (3) programmable critical frequency lockout ranges to prevent the drive from operating the load continuously at an unstable speed/load.
15. Seven (7) programmable preset frequencies/speeds.
16. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
17. PID functionality shall be included in the drive.
 - a. Programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped based on the level of a process feedback signal.
 - b. The drive shall include an independent PID loop for customer use, assigned to an Analog Output. This PID loop may be used for cooling tower bypass valve control, chilled water valve, etc.
18. At least 4 parameter user sets that can be saved to the permanent memory and recalled using a digital input, timed function, or supervision function.
19. Drive shall be compatible with an accessory that allows the control board to be powered from an external 24 VDC/VAC source, allowing the drive control to remain powered by a UPS during an extended power outage.
20. A computer-based software tool shall be available to allow a laptop to program the drive. The drive shall be able to support programming without the need for line voltage. All necessary power shall be sourced via the laptop USB port.
21. The drive shall include a fireman’s override mode. Upon receipt of a contact closure from the Fire Alarm Life Safety system, the drive shall operate in a dedicated Override mode distinct and separate from the drive’s Normal operation mode. The following features will be available in the drive override function:
 - a. The Override mode shall be secured by password to prevent changes once programmed.
 - b. The drive shall ignore external inputs and commands not defined as part of the override function.
 - c. Override operation mode shall be selectable between: single frequency, multiple fixed frequencies, follow an analog input signal, PID control, or come to a forced stop.
 - d. High priority safeties shall stop the drive and lower priority safeties shall be ignored in Override mode.
 - e. Drive faults shall be defined in Critical and Low priority groups. Critical faults shall stop the drive. Low priority faults shall be reset. Reset trials and timing shall be programmable.

- f. The drive shall be configurable to receive from 1 to 3 discrete digital input signals and operate at up to three discrete speeds.
22. The drive shall have multi-pump functionality and an intelligent master/follower configuration for controlling up to 8 parallel pumps equipped with drives. The drive shall have a parameter synchronization feature to program the PID, multi-pump, and AI parameters in all parallel drives. The functionality to start and stop the pumps based on capacity, operating time or efficiency of the pump to ensure each pump is operated regularly.
 - a. The multi-pump functionality shall control:
 - 1) Flow Control
 - 2) Pressure Control
 - 3) Pump Alternation

H. Security Features

1. The drive manufacture shall clearly define cybersecurity capabilities for their products.
2. The drive shall include password protection against parameter changes.
 - a. There shall be multiple levels of password protection including: End User, Service, Advanced, and Override.
 - b. The drive shall support a customer generated unique password between 0 and 99,999,999.
 - c. The drive shall log an event whenever the drive password has been entered.
 - d. The drive shall provide a security selection that prevents any "back door" entry. This selection even prevents the drive manufacturer from being able to bypass the security of that drive.
 - e. A security level shall be available that prevents the drive from being flashed with new firmware.
3. A checksum feature shall be used to notify the owner of unauthorized parameter changes made to the drive. The checksum feature includes two unique values assigned to a specific programming configuration.
 - a. One checksum value shall represent all user editable parameters in the drive except communication setup parameters. A second checksum value shall represent all user editable parameters except communication setup, energy, and motor data parameters.
 - b. Once the drive has been commissioned the two values can be independently saved in the drive.
 - c. The drive shall be configurable to either: Log an Event, provide a Warning, or Fault upon a parameter change when the current checksum value does not equal the saved checksum value.
4. The "Hand" and "Off" control panel buttons shall have the option to be individually disabled (via parameter) for drives mounted in public areas.
5. The capability to disable Bluetooth on control panels that include Bluetooth functionality shall be provided.

I. Network Communications

1. The drive shall have an EIA-485 port with removable terminal blocks. The onboard protocols shall be BACnet MS/TP, Modbus, and Johnson Controls N2. Optional communication cards for BACnet/IP, LonWorks, Profibus, Profinet, EtherNet/IP, Modbus TCP, and DeviceNet shall be available. The use of third party gateways are not acceptable.
2. The drive shall have the ability to communicate via two protocols at the same time, one onboard protocol and one option card based protocol. Once installed, the drive shall automatically recognize any optional communication cards without the need for additional programming.
3. The drive shall not require a power cycle after communication parameters have been updated.
4. The embedded BACnet connection shall be a MS/TP interface. The drive shall be BTL Listed to Revision 14 or later. Use of non-BTL Listed drives are not acceptable.
5. The drive shall be classified as an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
 - a. Data Sharing: Read Property Multiple-B, Write Property Multiple-B, COV-B
 - b. Device Management: Time Synchronization-B
 - c. Object Type Support: MSV, Loop
6. The drive's relay output status, digital input status, analog input/output values, Hand-Auto status, warning and fault information shall be capable of being monitored over the network. The drive's start/stop command, speed reference command, relay outputs and analog outputs shall be capable of being controlled over the network. Remote drive fault reset shall be possible.

J. Options (see schedule on drawings where applies):

1. Disconnect – A circuit breaker or disconnect switch shall be provided when indicated on the drive schedule. The disconnect shall be door interlocked and padlockable. Drive input fusing shall be included on all packaged units that include a disconnecting means. All disconnect configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label. Disconnect packages manufactured by anyone other than the drive manufacturer, are not acceptable.
2. Bypass – Bypass drive packages shall be provided when indicated on the drive schedule. All drive/bypass configurations shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label. Bypasses manufactured by anyone other than the drive manufacturer, are not acceptable.
 - a. The drive and bypass package shall be a complete factory wired and tested bypass system consisting of a padlockable disconnect device, drive output contactor, bypass contactor, and drive input fuses.
 - b. The drive and bypass package shall have a UL listed short circuit current rating of 100 kA, for 240 VAC and 480 VAC systems, and this rating shall be indicated on the rating label.

- c. The bypass control shall be powered by a three-phase switch mode power supply with a voltage tolerance of +30%, -35%. Single-phase power supplies and control power transformers (CPT) are not acceptable.
- d. The drive and bypass package shall be seismic certified and labeled to the IBC. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156. Seismic certification of equipment and components shall be provided by OSHPD preapproval.
- e. All bypass packages shall utilize a dedicated LCD bypass control panel (keypad) user interface. The bypass control panel must be a separate display from the drive control panel. Bypass packages that use a single shared drive/bypass control panel are not acceptable, due to that control panel acting as a single point of failure.
 - 1) The bypass shall include a two-line, 20-character LCD display. The display shall allow the user to access parameters and view:
 - a) Bypass input voltage, current (Amps) and power (kW)
 - b) Bypass faults, warnings, and fault logs
 - c) Bypass operating time and energy consumption (resettable)
 - 2) The bypass control panel shall include the following controls:
 - a) Four navigation keys (Up, Down, Enter, Escape)
 - b) Bypass Hand-Off-Auto, Drive mode / Bypass mode selectors, Bypass fault reset
 - 3) The following indicating lights (LED PTT type) or control panel display indications shall be provided.
 - a) Drive mode selected, Bypass mode selected
 - b) Drive running, Bypass running
 - c) Drive fault, Bypass fault
 - 4) Safety interlock and run permissive status shall be displayed using predetermined application specific nomenclature, such as: Damper end switch, smoke alarm, vibration trip, and overpressure.
- f. All bypasses shall have the following hardware features/characteristics as standard:
 - 1) Six (6) digital inputs and five (5) Form-C relay outputs. The digital inputs shall be capable of accepting both 24 VDC and 24 VAC. The bypass control board shall include an auxiliary power supply rated 24 VDC, 250 mA.
 - 2) Drive isolation fuses shall be provided. Bypass designs which have no such fuses, or that only incorporate fuses common to both the drive and the bypass are not acceptable. Third contactor "isolation contactors" and service switches are not an acceptable alternative to drive isolation fuses.
 - 3) The bypass shall be able to detect a single-phase input power condition while running in bypass, disengage the motor, and provide a single-phase input power indication.

- 4) The bypass shall be designed for stand-alone operation and be completely functional in both Hand and Automatic modes, even if the drive and/or drive's control board has failed. Network communications shall remain functional. Bypass systems that do not maintain full functionality in the event of a drive failure, are not acceptable.
- g. All bypasses shall have the following software features as standard:
- 1) Programmable loss-of-load (broken belt / coupling) indication shall be functional in drive and bypass mode.
 - 2) The bypass shall also support run permissive and start interlock control functionality, including start delay, as previously specified in the drive section.
 - 3) The bypass control shall monitor the status of the drive and bypass contactors and indicate when there is a welded contactor contact or open contactor coil.
 - 4) The bypass shall include a selection for either manual or automatic transfer to bypass. The automatic transfer mode shall allow the user to select the specific drive fault types that result in an automatic transfer to bypass. The automatic transfer mode shall not allow a transfer to bypass on motor related faults. Automatic transfer schemes that do not differentiate between fault types, are not acceptable.
 - 5) The bypass shall include the ability to select the operating mode of the system (Drive/Bypass) from either the bypass control panel or digital input.
 - 6) The bypass shall include a supervisory control mode that monitors the value of the drive's analog input (feedback). This feedback value is used to control the bypass contactor on/off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps.
 - 7) Selectable Class 10, 20, or 30 electronic motor overload protection shall be included in both drive and bypass mode.
 - 8) The drive and bypass shall be designed to operate as an integrated system when in Override mode. Whether operating in drive or bypass mode, the low priority safeties will be ignored, and high priority safeties will be followed. External start/stop commands will be ignored. There shall be four selectable Override modes:
 - a) Bypass only, with two smoke control modes:
 - (1) Fixed pre-configuration of digital inputs
 - (2) Configurable high/low priority safeties and faults, to allow configuration to meet needs of local Authority Having Jurisdiction.
 - b) Drive only
 - c) Drive then transfer to bypass, in the event of a drive fault
 - d) Force to Stop

- h. Network communications – the bypass shall include BACnet MS/TP, Modbus, and Johnson Controls N2 as standard. The bypass BACnet implementation shall be BTL Listed to Revision 14 or later. Optional communication cards for BACnet/IP, LonWorks, Profibus, Profinet, Ethernet/IP, Modbus TCP, and DeviceNet shall be available.
 - 1) The bypass relay output status, digital input status, warning and fault information can be monitored over the network. Status information shall be monitored, including operating mode (drive vs bypass), current drawn in bypass mode, broken belt, and phase-to-phase voltage. The bypass start/stop command, force to bypass command, and relay outputs shall be capable of being controlled over the network.

PART 3 - EXECUTION

3.1 EXECUTION

A. Sizing:

- 1. The drives shall be sized as required by the scheduled motors. See Mechanical and the Mechanical Drawing Schedules for motor information.
- 2. The drives shall be sized to continually operate the motors at continuously at the full rated horsepower at conditions scheduled on the drawings.
- 3. Either a variable or constant torque drive shall be selected based on the application and shall be provided as specified for each application.

B. Installation and Field Wiring:

- 1. Mounting and power wiring and power terminations shall be provided by Division 26.
- 2. Control wiring and control terminations shall be provided by Section 230923.
- 3. The variable frequency drives on air distribution equipment shall be installed out of the airstream so that setup and testing can be accomplished without disrupting system pressures and airflows. In some applications where is not practical, such as packaged equipment, the drives shall be furnished with a remote mounting keypad which shall be installed in the controls section of the cabinet or other suitable enclosure on the side of the unit.

C. Field Start Up and Testing

- 1. The start-up and testing is to be provided at the installation site by the manufacturer or other agent deemed acceptable by the Owner's Representative.
- 2. Verify all installation connections and controls.
- 3. Field adjust all safety controls.
 - a. For all drives with thermal overload protection, set and adjust drive program to thermally protect motor from overload conditions.
 - b. Check fuses for proper thermal protection of drive.

4. Field adjust all drive parameters (including acceleration and deceleration ramps and volts-to-hertz ratio for smooth operation).
5. For all drives with remote disconnect, confirm that local disconnect has an auxiliary switch and that the switch is wired to the drive to interrupt the drive when local disconnect is used to de-energize equipment. Interconnecting wiring provided by Division 26.
6. All mechanical components shall be adjusted for proper alignment.
7. Demonstrate satisfactory operation of drive including line reactors, filters, and the bypass contactor under full load rpm.
8. Submit start-up and test report in accordance with Section 230500.

D. Training

1. Provide in accordance with Section 230500.
2. Provide on-site operation and maintenance training by manufacturer or other agent deemed acceptable by the Owner's Representative.

END OF SECTION 23 0995

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Chilled Water, Glycol Chilled Water, Equipment Drain and Overflow Piping
- B. Unions, Flanges and Couplings

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230517 – Sleeves and Sleeve Seals for HVAC
- C. Section 230519 – Meters and Gauges for HVAC Piping
- D. Section 230529 – Hangers and Supports for HVAC Piping and Equipment
- E. Section 230548 – Vibration Isolation
- F. Section 230549 – Seismic Controls for Mechanical
- G. Section 230553 – Identification for HVAC Piping and Equipment
- H. Section 230700 – HVAC Insulation
- I. Section 230923 – Direct-Digital Control for HVAC
- J. Section 232116 – Hydronic Piping Specialties
- K. Section 232500 – HVAC Water Treatment

1.3 REFERENCES

- A. General
 - 1. ASME - Boiler and Pressure Vessel Codes, SEC 9 - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
 - 2. ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300
 - 3. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings
 - 4. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - 5. ASME B31.9 - Building Services Piping
 - 6. ASTM A53 - Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless

7. ASTM A234 - Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
8. ASTM B32 - Solder Metal
9. AWS D1.1 - Structural Welding Code

1.4 GENERAL

- A. All materials shall be compatible with ethylene and propylene glycol.

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Product Data: Include data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.

1.6 QUALITY ASSURANCE

- A. Welding Materials and Procedures: Conform to ASME SEC IX and applicable state regulations.
- B. Welders Certification: In accordance with ASME SEC IX.

1.7 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Record actual locations of piping.

1.8 QUALIFICATIONS

- A. Welders: Certified in accordance with ASME SEC 9 and AWS D1.1.

1.9 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 code for installation of piping system.
- B. Welding Materials and Procedures: Conform to ASME SEC 9 and applicable state and local labor regulations.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 230500.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.11 TESTING (REFER TO SECTION 230500)

- A. Test in the presence of the Owner's Representative.
- B. Systems:
 - 1. Chilled Water and Glycol Chilled Water
- C. Above Grade Piping Test
 - 1. Piping systems shall be tested with a hydrostatic test of not less than 125 psig. Due care shall be taken that equipment with a maximum working pressure which is less than the required test is removed from the line during the test. After the test is complete, the equipment shall be reinstalled and a test of the maximum working pressure of the equipment put on the connections to the respective equipment.
 - 2. Test piping prior to insulating.
- D. Submit certificate of tests to the Owner's Representative for review.
- E. Include certificate of tests in the Operation and Maintenance manual.

PART 2 - PRODUCTS

2.1 EQUIPMENT DRAIN AND OVERFLOW DRAIN (ABOVE GRADE)

- A. Type M copper tubing with soldered Joints. Minimum size $\frac{3}{4}$ ".

2.2 CHILLED WATER, AND GLYCOL CHILLED WATER

- A. Up to and including 2 inches:
 - 1. Copper tubing: ASTM B88; type L; hard drawn; fittings:
 - a. Solder wrought copper fittings, ASME B16.22; ASTM B32, 95-5 tin-antimony or tin and silver solder with melting range of 430 to 535 °F, lead-free. Fittings shall be full nominal diameter inside and long radius.
 - b. Copper press fittings with a factory installed EPDM sealing element. The sealing element shall, when unpressed, shall assure leakage of liquids to provide the installer quick identification of joints that have not been pressed prior to placing system into operation. Fittings shall be rated for a maximum of 300 psi. Viega ProPress or approved equal.
 - 2. Steel: ASTM A53; schedule 40 black; ASME B16.3 malleable iron fittings; 125 psi; threaded joints
- B. Pipe over 2 inches:
 - 1. ASTM A53; schedule 40 black; ASTM A234 forged steel welding type fittings

2. Copper pipe; ASTM B88; type L; hard drawn; soldered; ASME B16.22, Solder wrought copper fittings; ASTM B32, 95-5 tin-antimony, or tin and silver solder joints with melting range of rang 430 to 535 °F, lead free.
 3. Groove locked fittings and couplings: In lieu of welded flanged or soldered joints noted above, groove locked couplings as specified below may be used for piping systems which do not exceed the design parameters of the respective gasket.
 4. Manufacturers:
 - a. Victaulic
 - b. Gruv-Lok
- C. Copper press fittings and groove locked couplings shall only be used in mechanical equipment rooms and at major equipment connections where fittings and couplings are accessible.

2.3 PIPE HANGERS AND SUPPORTS

- A. Materials shall in accordance with Section 230529.

2.4 UNIONS, FLANGES, AND COUPLINGS

- A. Unions for Pipe 2 inches and under: 150 psig threaded malleable for ferrous piping; bronze with soldered joints for copper pipe.
- B. Flanges for Pipe over 2 inches: 150 psig forged steel slip-on or weld neck for ferrous piping; grooved flanges are not permitted; bronze for copper piping; ,gaskets shall be non-asbestos ring style for raised face flanges and non-asbestos full face style for flat face flanges suited for pressure, and fluid type.
- C. Grooved and Shouldered Pipe End Couplings (Steel) for Pipe over 2 inches:
1. Manufacturers (Refer to Section 230500):
 - a. Victaulic
 - b. Gruv-Lok
 2. Sealing Gasket: Grade E, EPDM, 150 psi, -30 to 230 °F
 3. Couplings:
 - a. Victaulic Style 75, 77, 72, and 750 for all pipe joint connections requiring movement/expansion/contraction/deflection (including heating water system)
 - b. Victaulic Style 07 "Zero Flex" rigid couplings for all pipe joint connections not requiring joint flexibility
 4. Accessories: Steel bolts, nuts, and washers
- D. Grooved and Shouldered Pipe End Couplings (Copper) for pipe over 2 inches:
1. Manufacturers (Refer to Section 230500):

- a. Victaulic
2. Sealing Gasket: Grade E, EPDM, 150 psi, -30 to 230 °F
3. Couplings:
 - a. Couplings for copper tubing shall be Style 606 "No-Sweat" and shall consist of a cast ductile iron housing conforming to ASTM A536 with a copper alkyd enamel paint coating.
 - b. Victaulic Flanged Connections shall be Style 641 "No Sweat" Vic Flange Adaptors. They shall engage directly into roll grooved copper tube and fittings and shall bolt directly to ANSI Class 125 cast iron and Class 150 steel flanged components.
 - c. Victaulic Fittings shall be Victaulic full flow copper fittings with grooves designed to accept Victaulic "No Sweat" grooved end couplings or flanges. Fittings for 2½ to 4 inch shall be copper per ASTM B75 and ASTM B584 for 5 to 6 inch sizes.
4. Accessories: Steel bolts, nuts, and washers
- E. Dielectric Connections: Union with galvanized or plated steel threaded end; copper solder end; water impervious isolation barrier.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Section 232500.
- F. Provide temporary piping connections for use in cleaning and flushing provided in Section 232500.

3.2 INSTALLATION – GENERAL

- A. Provide pipe as indicated on the drawings.
- B. Install in accordance with manufacturer's instructions and ASME B31.9.
- C. Route piping in orderly manner, parallel to building structure, and maintain gradient.

- D. Provide piping and all required offsets and fittings in order to coordinate with other trades, minimize structural inferences, conserve space, and maintain headroom. Refer to Section 230500 – Common Work Results for HVAC, paragraph Locations.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipe passing through partitions, walls and floors. (Refer to Section 230517)
- G. Provide supports, hangers (and spacing), insulation, shields, sleeves, escutcheons, and inserts in accordance with Section 230529.
- H. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 230700.
- I. Provide access doors where fittings are not exposed unless indicated to be provided under other divisions. Access doors shall comply with Division 8.
- J. Slope piping and arrange systems to drain at low points with drain valves. Use eccentric reducers to maintain top of pipe level.
- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- L. Prepare unfinished supports and devices for finish painting in accordance with Section 230553.
- M. Install control valves, sensor wells, flow meters, and any other hydronic devices provided under Section 230923 in accordance with the manufacturer's recommendations. Provide piping to hydronic differential pressure sensors provided under Section 230923. Control devices are sized in Section 230923. Provide adaptors from valve size to pipe size in the piping immediately at the valve connection points.
- N. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- O. Press fittings and grooved mechanical couplings and fasteners shall only be used in mechanical equipment rooms and at major equipment connections where fittings and couplings are accessible.
- P. Flanges / Unions:
 - 1. Steel Pipe:
 - a. Threaded pipe, 2 inches smaller: Install unions downstream of each valve with screwed joint upstream
 - b. Welded pipe, 2 ½ inches and larger: Flanged connections both sides of valve
 - c. Use unions at final connection to each piece of equipment or apparatus having a threaded pipe connection.

- d. Use flanges at final connection to each piece of equipment or apparatus having a flanged pipe connection.
2. Copper Pipe:
- a. Threaded pipe: Install union down stream of each valve with screwed joint up stream. Use brass male adapters each side of valve.
 - b. Soldered pipe: No unions required either side of valve.
 - c. Use unions at final connection to each piece of equipment or apparatus having a threaded pipe connection.
 - d. Use flanges at final connection to each piece of equipment or apparatus having a flanged pipe connection.
3. Notes to above: Temperature control valves shall have unions and/or flanges at each port. Valves with screwed connections that cannot be rotated shall have unions on each side of valve. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
- Q. Use non-conducting dielectric connections whenever jointing dissimilar metals.
- R. Hydrostatically pressure test and clean and flush prior to connection to campus utility (or existing piping in buildings).
- S. Test in presence of Owner's Representative. Provide copies of test to Owner's Representative and include in O & M Manual.
- T. After completion, fill, clean and treat systems. (Refer to Section 232500)
- U. Provide water taps for water treatment testing all all closed circulating pipe systems.
- V. Pipe condensate drip pans to drains.

END OF SECTION 23 2113

SECTION 23 2116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Air separators
- B. Air vents
- C. Expansion tanks
- D. Flow control balancing valves (automatic)
- E. Flow control balancing valves (manual)
- F. Relief valves
- G. Strainers
- H. Venturis

1.2 RELATED SECTIONS

- A. Section 23 05 00 – Common Work Results for HVAC
- B. Section 23 05 23 – General Duty Valves for HVAC Piping
- C. Section 23 21 13 – Hydronic Piping
- D. Section 23 25 00 – HVAC Water Treatment

1.3 REFERENCES

- A. ASME - Boilers and Pressure Vessel Codes, SEC 8-D-Rules for Construction of Pressure Vessels

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 23 05 00)

- A. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description, model and dimensions.
- B. Furnish a manufacturer's data report for Pressure Vessels, Form U-1 as required by ASME Boiler Pressure Vessel Code for each compression and expansion tanks.

- C. Submit Selections and sizing for all flow balancing valves (automatic or manual).
 - D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
 - E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.
- 1.5 PROJECT RECORD DOCUMENTS (REFER TO SECTION 23 05 00)
- A. Record actual locations of equipment and devices furnished under this section.
- 1.6 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 23 05 00)
- A. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- 1.7 DELIVERY, STORAGE, AND HANDLING (REFER TO SECTION 23 05 00)
- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
 - B. Provide temporary protective coating on cast iron and steel valves.
 - C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
 - D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 - PRODUCTS

2.1 AIR SEPARATORS

- A. Manufacturers (Refer to Section 23 05 00):
 - 1. Spirotherm
 - 2. TACO 4900 Series
- B. Construction and design:
 - 1. In-line design, 150 psi working pressure
 - 2. ASME SEC 8-D construction
 - 3. Brass construction for sizes 1½ inches and smaller
 - 4. Steel construction for sizes 2 inches and larger
 - 5. Turbulence suppressive type air eliminator to separate micro bubbles and to remove stationary air pockets through absorption

6. Copper or stainless steel coalescing medium
7. Integral brass venting mechanism at top of unit
8. Side valve to remove floating liquids and debris from the surface
9. Threaded blowdown connection port at bottom
10. Sized for maximum water velocity of 4 fps and maximum pressure drop of 1.5 feet WG.

2.2 AIR VENTS

A. Manufacturers (Refer to Section 23 05 00):

1. Bell and Gosset
2. Hoffman
3. Spirotherm
4. Taco
5. Caleffi
6. Nexus

B. Manual Type:

1. Basis of Design: Bell and Gossett, No. 4V
2. 1/8 inch coin or screwdriver operated, brass connection

C. Automatic Type:

1. Basis of design: Bell and Gossett, No. 87
2. Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure (150 psi at 240 °F minimum); with isolating valve
3. Air vent shall be tapped for 1/8 inch IPS.

D. Automatic Type: High Capacity

1. Basis of design: Bell and Gossett, No. 107A
2. Non-modulating high capacity air vent design to purge free air from the system and provide positive shutoff at pressures up to 150 psig at a maximum temperature of 250 °F. The design of the high capacity air vent shall prevent air from entering the system if system pressure should drop below atmospheric pressure. The high capacity air vent shall be pilot operated for intermittent purging of free air at pressures up to 2 psig during normal system operation, and diaphragm operated for full capacity purging of free air at pressures between 2 to 150 psig.

E. Manual Type: High Capacity

1. Short vertical sections of 2 inches diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber

2.3 EXPANSION TANKS

A. Manufacturers: (Refer to Section 23 05 00):

1. Amtrol
2. Armstrong
3. Bell and Gossett
4. Taco
5. Wessels

B. Construction:

1. Diaphragm type: Welded steel; tested and stamped in accordance with ASME SEC 8-Div. 1; cleaned; prime coated; fitted with lifting rings and steel support saddle; tappings for installation of accessories; supplied with National Board Form U-1; 125 psi pressure rating; heavy duty butyl rubber diaphragm; air charging valve (standard tire valve); tank drain.
2. Tank shall be full or partial acceptance as scheduled.

C. Accessories:

1. Manual air vent
2. Pressure relief valve: Select for pressures noted on the drawings.
3. Water pressure gauge: Install at system connection.
4. Air pressure gauge: charging valve indicated above shall be independent of gauge, and shall be accessible without removal of gauge.

2.4 FLOW BALANCING VALVES (AUTOMATIC)

A. Manufacturers (Refer to Section 23 05 00):

1. IMI Flow Design/Autoflow
2. Griswold
3. Nexus

B. Basis of Design: Autoflow Series YR

C. General: Pressure compensating; factory set to control within 5 % of selected rating at pressure differential of ten (10) times the minimum required full flow conditions. Valves shall be complete with flow control, two pressure/temperature test ports and ground joint union to allow field exchange of internal components without removing from pipeline. Unit shall be all brass and stainless steel.

D. Valves shall be marked externally with size, capacity and direction of flow.

2.5 FLOW CONTROL BALANCING VALVES (MANUAL) – “CIRCUIT SETTERS”

A. Manufacturers (Refer to Section 23 05 00):

1. Armstrong
 2. Bell and Gossett
 3. Nibco
 4. Taco
 5. Nexus
- B. General: Precision machined orifice with memory stop; calibrated external name plate and direction arrow. Flow control balancing valves shall have tight shut-off and 2 meter taps, each with internal check valve and thread protector. Component construction and materials shall be suitable for application.
- C. Valves Serving Design Flows of Greater than 30 gpm: Valve adjustment shall occur over a minimum of 720° adjustment rotation.
- D. Circuit Setters shall be sized for a minimum of 2 foot water pressure drop and a maximum of 5 foot drop at design flow rate.
- E. Connections:
1. Up to 2 inches: Threaded or sweat
 2. 2½ inches and larger: Flanged
- F. Flow control balancing valves shall be sized based on scheduled equipment flow rate according to the manufacturer's guidelines.

2.6 SAFETY RELIEF VALVES

- A. Manufacturers (Refer to Section 23 05 00):
1. Bell and Gossett
 2. Taco
- B. Basis of Design:
1. Bell and Gossett Series 790 and 1170
- C. Construction:
1. Body: Brass
 2. Diaphragm and Seat: EPDM
 3. Internal Wetted Parts: Brass
 4. ASME labeled, diaphragm assisted
 5. Maximum Working pressure 125 psig
 6. Maximum operating temperature 250 F
 7. Relief setting: As indicated on drawings

2.7 STRAINERS

A. Manufacturers (Refer to Section 23 05 00):

1. Sarco
2. Strong, Dunham Busch
3. Webster
4. Watson McDaniel
5. Nexus

B. Size 2 inch and under:

1. Basis of Design: Sarco IT, BT
2. Screwed brass or iron body for 250 psig working pressure Y pattern with 1/32 inch stainless steel perforated screen
3. Accessories: 3/4 inch blow-off valve and cap

C. Size 2½ inch to 8 inch:

1. Basis of Design: Sarco CI-125
2. Flanged iron body for 147 psig working pressure; Y pattern with 3/64 inch stainless steel perforated screen
3. Accessories: 3/4 inch blow-off valve and cap

D. Adjust screen mesh as required by equipment manufacturer that strainer serves if recommended by equipment manufacturer.

2.8 VENTURIS

A. Manufacturers (Refer to Section 23 05 00):

1. Barco
2. Hyspan
3. HCI
4. Nexus
5. Griswold

B. Precision machined orifice with tag indicating size and flow ratings. Fittings shall have two meter taps, each with shut-off cock and thread protector.

2.9 PUMP SUCTION FITTINGS

A. Provided under Section 23 21 23.

2.10 GLYCOL FILL ASSEMBLY

A. Provided under Section 23 25 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Provide specialties in accordance with manufacturer's instructions and as indicated on the drawings.
2. Where large air quantities can accumulate, provide enlarged air collection standpipes.
3. When pumps are piped in parallel, provide the following:
4. Shut-off valve(s), balance valve, non-slam check valve. (Combination valves are not allowed).

B. Air Separators:

1. Provide air separator on suction side of system circulation pump.

C. Air Vents:

1. Provide automatic air vents at high points in mechanical rooms, at coils in mechanical rooms, and where indicated on the drawings. Provide isolation ball valve at each vent for future service of vent.
2. Provide high-capacity air vent at the air separator, as specified with the air separator, and pipe to overflow tank.
3. Provide threaded ½ inch ball valve between high capacity and automatic air vents and line served. Pipe connection to be ½ inch minimum.
4. Provide manual air vents on all water coils and at high points of piping systems. All air vents shall have a manual shutoff.
5. Pipe or tubing of appropriate size shall be run from automatic vents to indirect waste in mechanical spaces. These lines shall be tagged with a label identifying the location of the automatic vent.

D. Flow Control Balancing Valves:

1. Provide flow control balancing valves at all water coils, pumps, re-circ pump, pipe mains and equipment as indicated.
 - a. Install flow control balancing valves with meter connections upward.
2. Valves shall be sized as noted in Part 2 Products. Provide concentric reducers on either side of valve when valve is smaller than line size.

E. Relief Valves:

1. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.

2. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
3. Install relief valves without a vertical lift on the outlet piping.
4. Pipe relief valve outlet to nearest floor drain for water systems or empty overflow tank for glycol systems.
5. Where location of glycol feeder will not allow relief piping to be installed without a vertical lift, provide a chemical drum adjacent to relief valve and pipe relief valve to the drum.
6. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas. Connections from the outlet to the manifold piping shall enter the manifold at an angle no greater than 45 degrees to the direction of flow.

F. Strainers:

1. Provide $\frac{3}{4}$ inch valved drain and hose connection on strainer blow down connection.
2. Provide strainer upstream of all control valves, coils, reducing valves, traps and other devices with orifices.

G. Venturis:

1. Install venturi flow devices with required straight lengths of piping upstream and downstream of valve according to the manufacturer's recommendations.

3.2 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections, 230800 and related sections

END OF SECTION 23 2116

SECTION 23 2123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Base-Mounted Circulating Pumps

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230513 – Common Motor Requirements for HVAC Equipment
- C. Section 230519 – Meters and Gauges for HVAC Piping
- D. Section 230523 – General Duty Valves for HVAC Piping
- E. Section 230548 – Vibration Isolation
- F. Section 230549 – Seismic Controls for Mechanical
- G. Section 230593 – Testing, Adjusting, and Balancing
- H. Section 230700 – HVAC Insulation
- I. Section 230995 – Variable Frequency Drives
- J. Section 232113 – Hydronic Piping
- K. Section 232116 – Hydronic Piping Specialties
- L. Section 232500 – HVAC Water Treatment

1.3 REFERENCES

- A. General
 - 1. UL 778 - Motor Operated Water Pumps
 - 2. NFPA 70 - National Electrical Code

1.4 SUBMITTALS (REFER TO SECTION 230500)

- A. General

1. Construction: Verify each component of the construction requirements of these specifications including casing, impeller, shaft, sleeve, ring, and seat materials. Indicate maximum continuous operating temperature and working pressures. Address requirements for suction and discharge tappings.
 2. Performance Information: Provide all information indicated in the equipment schedule for each pump as a minimum including shut-off head, efficiency, brake horsepower, motor horsepower, motor voltage, and motor phase. Impeller diameter shall also be indicated.
 3. Pump Curves: Provide certified pump curves for each pump with design flow and pressure plotted. Curves shall be provided on a chart with flow on the x-axis and pressure on the y-axis. Brake horsepower lines shall also be indicated on the chart sufficient to determine the approximate brake horsepower at any given point on the curve. Include NPSH curve when applicable.
 4. Accessories: Indicate all accessories to be provided with each pump.
- B. Base-Mounted Circulating Pumps: Indicate baseplate material and assembly. Address requirement for flexible coupling guard. Provide pump suction fitting information indicating body material and addressing strainer requirements as well as requirements for inlet vanes, removable magnetic insert, and adjustable support foot. Provide manufacturer's installation instructions, including recommended attachment and grouting of pump base.
- C. Seismic certification where applicable.
- D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.
- 1.5 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 230500)
- A. Include the following minimum information: All pump performance and pump curve information required for equipment submittals; installation instructions; assembly views; replacement parts; and lubrication instructions including lubrication points, type of lubrication to be provided, and frequency of lubrication.
- 1.6 REGULATORY REQUIREMENTS
- A. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.
- 1.7 EFFICIENCY STANDARDS
- A. Pumps that require a 15 % or greater increase in brake horsepower than the scheduled equipment to meet the design flow and pressure requirements will not be considered equal and will not be accepted.

1.8 EXTRA MATERIALS (REFER TO SECTION 230500)

- A. Provide one (1) spare set of mechanical seals for each pump.

1.9 DRAWING SCHEDULES

- A. Refer to drawings for specific capacities, dimensions, accessories, and other requirements supplemental to these specifications.

PART 2 - PRODUCTS

2.1 BASE MOUNTED END SUCTION CIRCULATING PUMPS

- A. Manufacturers (Refer to Section 230500):
 - 1. Armstrong Series 4030
 - 2. Bell & Gossett Series 1510
 - 3. Taco Series FE
- B. General: Base-mounted; single stage; end suction
- C. See Section 230549 for seismic design requirements for equipment.
- D. Construction: Cast iron casing with pedestal support feet; cast bronze impeller, dynamically balanced and keyed to shaft; stainless steel or replaceable bronze shaft sleeve; carbon seal ring and ceramic seat; drain port; structural or fabricated steel baseplate and securely welded cross-members; flexible coupling with ANSI/OSHA guard; 175 psi maximum working pressure; 225 °F maximum continuous operating temperature. Permanently sealed, grease or oil-lubricated ball bearings.
- E. Pump casing shall have suction and discharge gauge tapings.
 - 1. Exception: Pumps that do not have gauge tapings shall be provided with gauge tapings in the connected piping on both the suction and discharge sides.
- F. Pump Suction Fitting: Angle pattern; cast iron body; inlet vanes; cylinder strainer with 3/16 inch diameter openings; disposable fine-mesh strainer over cylinder strainer; magnetic insert removable for cleaning; adjustable support foot.
 - 1. Exception: Pump suction fittings that do not have an integral support foot shall be provided with an adjustable pipe stand.

2.2 VFD CONTROLLED PUMPS

- A. All VFD controlled pumps (see VFD schedules on drawings) shall be provided with shaft grounding rings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify that electrical power is available and of the correct characteristics.

3.2 GENERAL

- A. Provide pumps in accordance with manufacturer's instructions and as indicated.
- B. Coordinate with Division 26 to ensure pumps are installed with sealproof electrical cord with 24" service loop to facilitate maintenance.
- C. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
- D. When pump connections are smaller than piping line-size, decrease from line size with long radius reducing elbows or reducers. Pipe-size reduction shall occur near the pump connection, with all valving associated with the pump being of piping line-size.
- E. Support piping adjacent to pump such that no weight is carried on pump casings.
- F. Provide air cock and drain connection on horizontal pump casings.
- G. Lubricate pumps before start-up.
- H. Provide single pressure gauge at each pump with isolation gauges to isolate total, suction and discharge pressures. See Section 230519.

3.3 BASE MOUNTED CIRCULATING PUMPS

- A. Provide supports under elbows on pump suction and discharge line for pipes size 4 inch and over. Refer to Section 230548.
- B. Provide line-size shut-off valve and pump suction fitting on pump suction. Provide separate line-size shut-off valve (and non-slam check valve where indicated) on pump discharge.
- C. For Base Mounted End Suction Pumps, the Manufacturer's representative shall check, align, and certify alignment of base mounted pumps prior to start-up and provide start-up services. Measure vibration on pumps to insure it is within limits of Section 230548 and the manufacturer requirements. Submit start-up reports to the Owner's representative.
- D. Install on concrete housekeeping base with anchor bolts. Set and level, and grout in place. Refer to Division 03.
 - 1. Exception: Pumps shown on drawings to be mounted on inertia bases. Refer to Section 230548.

- E. Connect piping to pump with flexible stainless steel braided pipe connectors. See Section 230548.
- F. Start-up strainers in end suction diffusers shall be removed from the system after cleaning and flushing and strapped to the pipe or end suction diffuser.

3.4 FACTORY AUTHORIZED AND WARRANTED START-UP

- A. Contractor shall include factory authorized/warranted start-up for the base mounted end suction pumps, sump pumps and associated controls to conform with the requirements of these contract documents and with manufacturer's recommendations.

3.5 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections

END OF SECTION 23 2123

SECTION 23 2300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Refrigerant
- B. Refrigerant Piping
- C. Piping supports and inserts

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230517 – Sleeves and Sleeve Seals for HVAC
- C. Section 230529 – Hangers and Supports for HVAC Piping and Equipment
- D. Section 230548 – Vibration Isolation
- E. Section 230549 – Seismic Controls for Mechanical
- F. Section 230700 – HVAC Insulation
- G. Section 238126 – Split System Air Conditioners

1.3 REFERENCES

- A. General
 - 1. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
 - 2. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
 - 3. AWS A5.8 - Brazing Filler Metal
 - 4. UL 429 - Electrically Operated Valves
- B. Piping
 - 1. ASME B31.5 - Refrigeration Piping
 - 2. ASME B31.9 - Building Services Piping

1.4 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Shop Drawings: Submit schematic layout of system, including pipe sizes, risers, valves, specialty devices, equipment and critical dimensions. Layout shall be reviewed and approved by the supplier of the respective equipment (air cooled condensing units and air handling units).
- B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- C. Design Data: Submit design data indicating pipe sizing.
- D. Test Reports: Indicate results of leak test, acid test.
- E. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- F. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- G. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Record exact locations of equipment and refrigeration accessories on record drawings.

1.6 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 230500)

- A. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

1.7 REGULATORY REQUIREMENTS

- A. Conform to ASME B31.9 for installation of piping system.
- B. Products Requiring Electrical Connection: Listed and classified by UL, as suitable for the purpose indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site under provisions of Section 230500.
- B. Deliver and store piping and specialties in shipping containers with labeling in place.
- C. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

- D. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All specialty devices shall be suitable for system operating pressures and temperatures.

2.2 REFRIGERANT PIPING

- A. Copper Tubing:

1. ASTM B280 and ANSI B9.1
2. Nitrogenized type ACR hard drawn or annealed
 - a. The use of annealed (soft copper) piping is restricted to use of ductless splits 2 tons and less.
 - b. Annealed piping shall not be used for the following applications: Variable refrigerant flow (VRF/VRV) systems between the outdoor unit and the branch controller, piping that is uninsulated, piping that is located on the roof, piping located in mechanical rooms
3. Rated for use for 700 psig maximum working pressure at 250 degrees F

- B. Fittings: ASME B16.22 wrought copper, long radius elbows

1. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy melting range 1,190 to 1,480 degrees F (640 to 805 degrees C).
2. Traps: Standard one piece

2.3 REFRIGERANT

- A. Refrigerant: ASHRAE 34. Type as specified for each type of equipment.

2.4 PIPING SUPPORTS AND INSERTS

- A. In accordance with Section 230500.

2.5 REFRIGERANT PIPING FLEXIBLE CONNECTORS

- A. Mason ULCPS or approved equal.
- B. Stainless steel braided hose with copper female sweat ends, UL approved for refrigerant service for pressures, temperatures and refrigerant type.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Ream pipe and tube ends. Remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

- A. Provide refrigeration piping and specialty devices required for a complete operating systems as required by the condensing unit and air handling unit manufacturer.
- B. Where isolation valves, driers, etc. are an integral piece of the equipment, additional shall not be required.
- C. Install refrigeration specialties in accordance with manufacturer's instructions.
- D. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- E. Install piping to conserve building space and not interfere with use of space.
- F. Group piping whenever practical at common elevations and locations. Slope piping one (1) % in direction of oil return.
- G. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- H. Pipe Hangers and Supports Inserts: Provide in accordance with Section 230529.
- I. Provide clearance for installation of insulation and access to valves and fittings.
- J. Insulate piping and equipment; refer to Section 230700.
- K. Follow ASHRAE 15 procedures for charging and purging of systems and for disposal of refrigerant.
- L. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
- M. Anchor pipe near each flexible connector.
- N. Refrigerant piping below grade shall be installed in PVC conduit with long sweep bends. See drawings for installation details.

- O. Slope suction lines down toward compressor 1 inch per 10 feet. Locate traps at vertical rises against flow in suction lines.
- P. Refrigeration system connections shall be copper to copper type properly cleaned and brazed. Use flux only where necessary.
 - 1. No soft solder connections will be allowed in system. If used, refrigerant piping will be rejected and will be required to be re-piped with new piping and brazed joints.
- Q. Braze valve, sight glass, and flexible connections.
- R. Circulate dry nitrogen through tubes being brazed to eliminate formation of copper oxide during brazing operation.
- S. Anchor pipe near each flexible connector.
- T. Fully charge completed systems with refrigerant after testing.
- U. Power and control wiring to devices furnished under this section shall be provided under this section in accordance with Division 26 requirements.

3.3 FIELD QUALITY CONTROL

- A. Make evacuation and leak tests in presence of Architect's Engineer after completing refrigeration piping systems. A positive pressure test will not suffice for the procedure outlined below.
 - 1. Leak test the system by charging the system to a pressure of 10 psig with refrigerant, with the compressor suction and discharge valves closed and with all other system valves open. Increase pressure to 300 psig with dry nitrogen. Rap all joints with a mallet and check for leaks with an electric leak detector having a certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.
 - 2. Draw vacuum on each entire system with vacuum pump to 200 microns using a vacuum gauge calibrated in microns. Do not use cooling compressor to evacuate system nor operate it while system is under high vacuum.
 - 3. Break vacuum with refrigerant to be used and re-establish vacuum test. Vacuum shall hold for twenty-four (24) hours at 200 microns without compressor running.
 - 4. Conduct tests at 70 °F ambient temperature or above.
 - 5. Do not run systems until above tests have been made and systems started up as specified. Inform Owner's Representative of status of systems at time of final inspection and schedule start-up testing if prevented by outdoor conditions before this time.
 - 6. After testing, fully charge system with refrigerant and conduct test with Halide Leak Detector.

- 3.4 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING
- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
 - B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
 - C. Provide building commissioning support as specified in Sections 23800 and related sections.

END OF SECTION 23 2300

SECTION 23 2500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Cleaning of piping systems
- B. Chemical feeder equipment
- C. Chemical treatment
- D. Equipment, valves, controls and connections to systems
- E. Electrical wiring of components to source unless indicated otherwise

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230923 – Direct-Digital Control for HVAC

1.3 REFERENCES

- A. NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Submit under provisions of Section 230500.
- B. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- C. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- D. Cleaning and flushing plan.
- E. Manufacturer's Field Reports (Refer to Section 230500):
 - 1. Indicate analysis of existing systems prior to making connections to new systems in accordance with Section 230505.
 - 2. Indicate start-up of treatment systems when completed and operating properly.
 - 3. Indicate analysis of system water after cleaning and after treatment.

- F. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- G. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Record actual locations of equipment and piping, including sampling points and location of chemical injectors.

1.6 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 230500)

- A. Operation and Maintenance Data: Include data on chemical feed pumps, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations. Include the volume of each system.

1.7 QUALIFICATIONS

- A. Manufacturers-Chemicals: Company specializing in manufacturing the products specified in this section with minimum five (5) years documented experience. Company shall have local representatives with State Certified Laboratories and full time service personnel in the area of the job site.
- B. Installer: Company specializing in performing the work of this section with minimum five (5) years documented experience and who is approved by manufacturer.

1.8 QUALITY ASSURANCE

- A. Start-up, system check, water samples, analysis, cleaning, flushing, and testing shall be performed by a single water treatment company for undivided responsibility.
- B. Company shall only utilize qualified personnel active in the field of water treatment who are factory trained or authorized.
- C. Analysis, testing and reports shall be performed by a State Certified Lab.

1.9 REGULATORY REQUIREMENTS

- A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and to public sewage systems. Provide means for off-site disposal when required by Ellensburg Waste Water Department.
- B. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose specified and indicated.

1.10 MAINTENANCE SERVICE

- A. Furnish service and maintenance of treatment systems for one (1) year from Date of Substantial Completion.
- B. Provide technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report to the Owner's representative after each visit.
- C. Schedule:
 - 1. Closed loop systems; a minimum of four visits on a quarterly basis for the first year. After the first year, CH2O (Derry Jeffries; 509-961-8729; djefferis@ch2o.com) will provide service of system.
- D. Provide laboratory and technical assistance services during this maintenance period.
- E. Include training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems in accordance with Section 230500. Arrange course to occur at start-up of systems.
- F. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.

1.11 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of Section 230500.
- B. Provide sufficient chemicals for treatment and testing for one year from the date of substantial completion.

1.12 DEFINITIONS

- A. Piping systems within this section shall be defined as follows:
 - 1. Chilled Water will include:
 - a. Chilled Water (CW)
 - b. Glycol Chilled Water (GCW)

PART 2 - PRODUCTS

2.1 WATER TREATMENT MANUFACTURERS/INSTALLERS (REFER TO SECTION 230500):

- A. Flint Services

B. King Soft Water

2.2 MATERIALS

A. System Cleaner:

1. Manufacturers (Refer to Section 230500):
 - a. Flint Services, Inc. Product SP-125DetSol
 - b. Nalco/Ecolab
2. A phosphate wetting agent combined with an alkaline surfactant with a sodium carbonate type alkalinity supplement introduced as necessary to produce 600 ppm of phenolphthalein alkalinity. Chemicals shall be non-toxic.

B. Closed System Treatment (Glycol Chilled Water, Chilled Water):

1. Manufacturers (Refer to Section 230500):
 - a. Flint Services, Inc., Product CS-537
 - b. King Soft Water: CST-N25
2. Chemical properties:
 - a. Ferrous metal corrosion inhibitor product shall provide corrosion protection by the use of sodium molybdate, sodium nitrate, and sodium borate technique.
 - b. Non-ferrous metal corrosion inhibitor product shall provide corrosion protection by the use of tolytriazole.
 - c. System shall be treated with biocides to prohibit biological growth within the closed system.
 - d. Sequestering agent to reduce deposits and control PH.
3. Campus Chilled Water is treated at the central plant. Provide enough chemical to the Owner to treat the volume of water required to fill the piping systems installed under this contract.

C. Freeze Protection

1. Manufacturers (Refer to Section 230500):
 - a. DowFrost HD
 - b. Interstate Chemical, Product P-300
 - c. Houghton Safety Therm HD
2. System shall be charged with an inhibited propylene glycol mixed with demineralized water.

2.3 BY-PASS (POT) FEEDER

- A. Manufacturers (Refer to Section 230500):
 - 1. JL Wingert
 - 2. Neptune
 - 3. Advantage Controls
 - 4. Flint Services

- B. Quick opening cap for working pressure of 175 psig. Sizes as scheduled below:
 - 1. System volume up to 200 gallons: 1 gallon pot feeder
 - 2. System volume greater than 200 gallons and less than 2000 gallons: 2 gallon pot feeder
 - 3. System volume greater than 2000 gallons: 5 gallon pot feeder

2.4 GLYCOL MAKE-UP FEEDER

- A. Manufacturers (Refer to Section 230500):
 - 1. PulsaFeeder, Model GF-1
 - 2. JL Wingert
 - 3. Advantage
 - 4. Flint Services
 - 5. Wessels
 - 6. Axiom

- B. The glycol system shall have the following features with all components mounted on a welded steel stand.
 - 1. Tank (heating systems where reliefs are pumped back into the tank): 50 gallon carbon steel
 - 2. Tank (all other systems): 50 gallon polyethylene
 - 3. Pump: positive displacement
 - 4. Controller: NEMA 1 enclosure
 - 5. Electrical:
 - a. 120 volts, single phase, 60 Hz
 - b. Cord and Plug: Provide unit with 6 foot cord and plug for connection to electric wiring system including grounding connector.
 - c. Single point electrical connection

 - 6. Features:
 - a. Pressure switch factory set: 0-100 psig (field adjustable). Pump shut-off valves
 - b. Pump discharge check valve
 - c. Low water pump protection
 - d. Relief valve
 - e. Pressure gauges
 - f. Power light, pump light, alarm light

- g. Drain valve
- h. Removable tank cover

7. Accessories

- a. Dry contacts for low water level alarm to be monitored by the building temperature control system.

2.5 GLYCOL RECOVERY TANK

- A. Provide empty spare tank for acceptance of glycol from safety relief valves, minimum 50 gallons, polyethylene, closed/removable top with minimum (2), 2" openings.

2.6 TEST EQUIPMENT

- A. Basic water test equipment shall be provided for determination of treatment residuals. This shall include a carrying case and reagents for use with the supplier's products. Where specialized or supplementary equipment is required, it shall be furnished as of the offering.
- B. Test equipment for glycol shall be furnished and approved by the glycol manufacturer.
- C. Corrosion Test Coupon Assembly: Constructed of corrosion material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.
 - 1. Two-station rack for closed loop systems.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Prior to water treatment being performed for closed loop systems the Division 23 and Section 230923 contractors shall provide documentation that all control valves are connected and in operation and verify that all valves are in the open position for complete circulation of cleaning chemical. Performing a cleaning procedure with closed valves may result in contamination of system glycol solution. Documentation shall be provided at the end of work prior to commencement of the water treatment work.
- B. Systems shall be operational, filled, hydrostatically tested, started, and vented prior to cleaning. Use water meter to record capacity in each system. Record capacity and include in Operation and Maintenance Manuals.
- C. Mechanical Contractor shall make temporary piping connections, contractor providing work in this section shall furnish temporary pumps, and temporary bypass filter as required to properly accomplish all cleaning operations.

- D. Place all manual and control valves serving main coil banks and terminal control units in open position during cleaning so that circulation through the mains and the runouts is obtained during cleaning.
- E. Initially flush the system with cold water through temporary flushing and drain connection. Flushing shall be sufficient to remove all contaminants, such as cuttings, filings, lubricants, rust, scale, grease, solder, flux, welding residue and debris.
- F. Verify that electric power is available and of the correct characteristics.
- G. Prior to introduction of demineralized water to systems treated with glycol, show demineralization equipment being utilized for the project to the Owner's Representative to obtain sign-off from Owner's Representative and include with start-up reports. Verify that a 5-micron filter is installed after the DI equipment (tanks) to ensure that no resin is introduced to piping system due to tank malfunction.

3.2 CLEANING AND FLUSHING WORK PLAN

- A. The chemical treatment contractor shall develop a project specific work plan for cleaning and flushing. The treatment plan shall be coordinated with the piping contractor prior to submission to the Owner's representative.
- B. Work plan shall be submittal with chemical treatment products. Submittals that do not include a treatment plan will be rejected and returned to the contractor without review.
- C. The work plan shall include:
 - 1. Condition of existing campus chilled water.
 - 2. Drawings indicating phasing and duration for input into the general contractors work schedule. Cleaning and flush for each phase shall be indicated on a set of piping plans with each phase of work clearly identified.
 - 3. Flushing schedule and drawings or diagrams that will be used for inspection and sign off prior to and after procedure, at Owner's option.
 - 4. Duration of flushing for each pipe system type
 - 5. Repeat flushing (if required to due to phasing).
 - 6. Specific procedures used for cleaning and flushing.
 - 7. Flushing velocities and flow rates with calculations, drawings and diagrams showing sectioning or zoning of piping systems to achieve required velocities, locations and means of temporary bypasses and returns.
 - 8. Temporary piping connections, temporary pumps and temporary bypass filters. Temporary pump motor size and power source.
 - 9. Cleaning treatment products
 - 10. Post treatment chemicals
- D. Provide the CX agent with minimum two weeks notice in advance of each cleaning and flushing activity. Schedule activities during normal business hours as much as practical.

3.3 CLEANING SEQUENCE

A. Piping Systems Requiring Cleaning

1. All hydronic cooling (all chilled water systems. The work also includes any existing piping to which the new system is connected or any sections of the existing chilled water lines in the campus chilled water distribution system if those lines must be drained and left empty for more than 7 days.

B. Documentation and Notification

1. The contractor is to submit a list showing what chemicals are to be used and in what concentrations (MUST include data and instruction sheets on each chemical and their MSDS forms) for each system to be cleaned and treated, a minimum of two weeks prior to cleaning. 24 hours prior to cleaning, the Owner needs to be notified of the start of the cleaning process and its duration. Documented process and test results with certificates stating the date, time, system cleaned and treated and testing results.

C. Final Acceptance

1. The cleaning and flushing must be complete, as well as Testing, Adjusting, and Balancing. If the balancer finds dirt, sludge, oil, cuttings, fittings, rust, scale or other such debris, the affected system is re-cleaned.

D. Concentration:

1. Concentration shall be as recommended by the approved cleaning chemical manufacturer for all systems.

E. Chilled Water and Glycol Chilled Water Systems:

1. Completely fill the system with recommended concentration of cleaning solution and circulate throughout the system to assure a rapid, efficient clean-up of all suspended solids and foreign material present in the system.
2. Circulate for twenty-four (24) hours, then drain systems as quickly as possible.
3. Refill with clean water and flush via the flushing and draining connections for a minimum one (1) hour duration.
4. Maintaining a full system and continuing the fresh water flush, operate the circulating pump, partially close and reopen all manual valve several times, operate all automatic control valves through several cycles and continue this operation until no further traces of cleaning compound are detected and until there is no evidence of particulate matter in the system.
5. Drain the system. Clean all strainers. After cleaning strainers and removal of start-up strainers, refill the system with clean water, circulate for thirty (30) minutes and drain system. Following the final flushing operation, fill the piping with fresh water.
6. Valve off coils, remove strainer for cleaning. Open supply isolation valve and drain until clear, then close supply valve. Open return isolation valve and drain until clear, then close return valve. Replace strainer and open isolation valves.

- F. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
- G. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.
- H. Add specified treatment chemicals as soon as possible after cleaning and flushing. Treatment chemicals must be added within two (2) hours of filling system with clean water.
- I. The cleaning firm shall, upon completion of cleaning and chemical treatment addition, tag each system so that tag is plainly visible as follows: "THIS SYSTEM HAS BEEN CHEMICALLY CLEANED AND TREATED". Each strainer shall additionally be tagged indicating strainer has been cleaned and date of cleaning.

3.4 INSTALLATION

- A. Furnish and install all devices as specified in this section and indicate on the drawings in accordance with manufacturer's instructions.
- B. All piping and wiring for chemical treatment shall be provided under this section unless indicated otherwise on the drawings.
- C. Systems shall be complete and shall be installed in strict accordance with the manufacturer's diagrams and recommendations; including all piping and electrical work.
- D. The manufacturer's representative shall be responsible for assisting the contractor during construction and shall charge the systems.

3.5 CLOSED SYSTEM TREATMENT

- A. Provide bypass pot feeder for each system when indicated on the drawings. Install isolating and drain valves and necessary piping. Pipe bypass feeder drain valve to the nearest floor drain. Install with the inlet of the feeder connected to the discharge side of the pump and the outlet of the feeder connected to the suction side of the pump.
- B. Introduce closed system treatment through bypass feeder (or glycol make-up feeder) when required or indicated by test.
- C. Freeze Protection:
 - 1. Introduce inhibited glycol solution through the glycol make-up feeder.
 - 2. Introduce inhibited glycol from a solution tank through a solution metering pump as indicated by the system pressure switch. Install as detailed on the drawings.
 - 3. Charge the following systems to the glycol concentrations indicated:
 - a. Glycol Chilled Water: 30%
 - b. Campus Chilled Water: No Glycol

4. Provide high temperature, corrosion resistant glycol recovery tank for each glycol system in the mechanical room for acceptance of glycol solution from safety relief valves and air vents.
 5. Install per manufacturer's recommendations adhering to compatible make-up water and inhibitor requirements.
- D. Provide ¾ inch water coupon rack around circulating pumps as indicated on plans with space for 4 test specimens to monitor system scale and corrosion.

3.6 SUPPLEMENTAL REQUIREMENTS

- A. At project closeout, installer shall be represented at final observation meeting by qualified personnel with equipment and two (2) copies of start-up reports.
1. Owner's Representative may choose and direct spot checking of system cleaning via strainer removal & blow-down. Systems not observed to be cleaned shall be re-drained, cleaned and flushed with appropriate chemicals re-introduced into system. This shall occur at no additional cost to the Owner.

3.7 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 2500

SECTION 23 3100 - HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. General Materials
- B. Medium velocity ductwork and fittings

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230517 – Sleeves and Sleeve Seals for HVAC
- C. Section 230529 – Hangers and Supports for HVAC Piping and Equipment

1.3 REFERENCES

- A. ASTM A 36 - Structural Steel
- B. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
- C. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
- D. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality
- E. ASTM A 525 - General Requirements for Steel Sheet, Zinc- Coated (Galvanized) by the Hot-Dip Process
- F. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality
- G. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate
- H. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Material
- I. NFPA 90A - Installation of Air Conditioning and Ventilating systems
- J. SMACNA - HVAC Air Duct Leakage Test Manual
- K. SMACNA - HVAC Duct Construction Standards - Metal and Flexible
- L. UL 181 - Factory-Made Air Ducts and Connectors

1.4 PERFORMANCE REQUIREMENTS

- A. Drawings showing duct arrangements are diagrammatic only and do not attempt to show all offsets and fittings required. The contractor shall adjust the work as required to facilitate installation, COORDINATE WITH STRUCTURE AND OTHER TRADES. See Section 230500, - "Locations".
- B. If changes of duct configuration or sizes are required to facilitate installation, obtain written permission from Owner's Representative before proceeding with fabrication and installation.

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual. Furnish for O&M Manual.
- B. Submit manufactured medium pressure ductwork and fittings.
- C. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- D. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 PROJECT RECORD DOCUMENTS (REFER TO SECTION 230500)

- A. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.7 QUALITY ASSURANCE

- A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and Flexible. - Latest Edition.
- B. Maintain one copy of document on site.

1.8 REGULATORY REQUIREMENTS

- A. Construct ductwork to the International Mechanical Code, and SMACNA, HVAC Duct Construction Standards - Metal and Flexible, Latest Edition
- B. Where more than one standard is referenced, the most restrictive shall apply.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures during and after installation of duct sealants.

1.10 DELIVERY, STORAGE AND HANDLING:

- A. Where possible, store products inside and protect from weather. Where necessary to store outside, store above grade and enclose with a vented waterproof wrapping.
- B. Ductwork shall be protected and handled in accordance with SMACNA Intermediate Level of duct cleanliness for new construction. See Section 230500 for additional requirements.

PART 2 - PRODUCTS

2.1 GENERAL MATERIALS

- A. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having G60 zinc coating in conformance with ASTM A90.
- B. Steel Ducts: ASTM A366.
- C. Sealants for metal ductwork:
 - 1. Sealant Class A, B and C: Hardcast, Duradyne, Ductmate, or approved equal.
 - 2. Exterior Systems:
 - a. Hardcast Inc. DT-Tape and RTA-50 adhesive two-part sealing system, or Hardcast Inc. Aluma-Grip 701 pressure sensitive rolled sealant tape.
 - 3. Non-hardening, water resistant, fire resistive, compatible with mating materials.
 - 4. Sealant shall be compositely tested for fire and smoke hazard ratings according to recognized standard testing methods (ASTM E84) and shall have ratings not exceeding flame spread 25, fuel contributed 50 and smoke developed 50.
 - 5. Sealants used on all non-exterior ductwork shall be water based (no solvents)
- D. Hanger Rod: ASTM A36; galvanized steel; threaded both ends, threaded one end, or continuously threaded.

2.2 MEDIUM VELOCITY DUCTWORK AND FITTINGS

- A. Medium velocity ductwork shall be defined as all ductwork connecting to the air handling unit.

- B. Fabricate, install, and support in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, the International Mechanical Code, and as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures.

PART 3 - EXECUTION

3.1 INSTALLATION-GENERAL

- A. Provide in accordance with manufacturer's instructions and as indicated on the drawings.
- B. Install and seal ducts in accordance with Washington State Energy Code and SMACNA HVAC Duct Construction Standards - Metal and Flexible and as specified for the specified pressure class and sealant class.
- C. Duct Sizes are gross outside dimensions. Where ductwork is indicated on the drawings to be lined, an allowance for 1 inch insulation has been included and duct sizes do not need to be increased to compensate for the insulation. Note: Internally insulated ductwork incorporating 2 inches of internal lining has been utilized in selected locations as noted on the drawings (duct sizes do not need to be increased to compensate for the 2 inch insulation).
- D. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- F. Use double nuts and lock washers on threaded rod supports.
- G. Low velocity plenums:
 - 1. Construct with angle iron framing suitably reinforced to prevent sagging, breathing or vibration. The building structure shall not be used as walls or ceilings or plenums unless specifically indicated. All portions of the plenums shall be ½ inch minimum clearance from building structure.
 - 2. Where plenums are indicated to be fastened to the building floor, plenum construction shall be angle iron frame bolted to the floor with caulking compound applied before tightening.
 - 3. When plenums are not indicated to be set on the floor, the bottom of the plenum shall have additional angle iron bracing than required by ducts of the same size. Connect air inlets and outlets to low pressure ducts with 5 feet maximum length of flexible duct held in place with strap or clamp.
- H. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

- I. Internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation, in accordance with SMACNA Intermediate Level of duct cleanliness for new construction.
- J. Make required offsets and transitions in ductwork in accordance with Section 230500 (“Locations”) and this section. Offsets shall be the least angle possible. Changes shall be submitted to the Owner’s representative in shop drawing form before proceeding with the work so that the effects of offsets on system performance can be evaluated.

3.2 INSTALLATION-MEDIUM VELOCITY DUCTWORK

- A. Bullhead and straight tees will not be permitted.

3.3 CLEANING

- A. Ducts which accumulate dust and debris during construction shall be cleaned by the Contractor at no expense to the Owner.
 - 1. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with temporary filters, or bypass during cleaning.
 - 2. Ductwork which does not become clean by the above method shall be cleaned with high power vacuum machines. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

3.4 SCHEDULES

- A. Provide duct materials in accordance with schedule below.
- B. Apply sealants to all ductwork in accordance with the schedule.
 - 1. Fittings and joints that are continuously welded ductwork do not require sealant.
- C. Ductwork Material and Pressure Class Schedule

Air System	Pressure Class inches WG	Material
Medium Velocity	6 Positive or Negative	Galvanized Steel

- D. Sealants - Metal Ductwork
 - 1. Seal ductwork in accordance with table below.
 - 2. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage.
 - 3. Pressure sensitive tape is not an approved sealing method.

4. All connections shall additionally be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels and duct connections to equipment.
5. Sealants that would void the product listings is not required.
6. Spiral lock seams need not be sealed except at transverse joints and fittings.
7. Fittings and joints that are continuously welded ductwork do not require sealant.

Pressure Class inches WG	Sealant Class	Description
Up to 2	Class C	Seal all transverse joints and longitudinal seams with Class C sealant.
3	Class B	Seal all transverse joints and longitudinal seams with Class B sealant.
4 and Greater	Class A	Seal all transverse joints, longitudinal seams, and ductwall penetrations with Class A sealant.

3.5 FIELD QUALITY CONTROL

A. Testing (Refer to Section 230500)

1. Supply and Return Duct connections to the AHU shall be visibly inspected for leakage while system is operating. Any air noise from leaks at the duct transition connections to the AHU shall be sealed air-tight.:

3.6 EQUIPMENT MANUFACTURER’S AND CONTRACTOR’S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800and related sections.
- C. Provide building commissioning support as specified in Sections 230800and related sections.

END OF SECTION 23 3100

SECTION 23 4000 - AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Disposable, Extended Area Panel Filters
- B. Disposable Panel Filters
- C. Filter Gauges

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 237300 –Central Station Air Handling Units

1.3 REFERENCES

- A. ARI 850 - Commercial and Industrial Air Filter Equipment
- B. ASHRAE 52 - Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter
- C. UL 586 - Test Performance of High Efficiency Particulate Air Filter Units
- D. UL 900 - Test Performance of Air Filter Units

1.4 PERFORMANCE TOLERANCES

- A. Conform to ARI 850 Section 7.4
- B. Dust Spot Efficiency: Plus or minus 5 %

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. Provide data on filter media, filter performance data, filter assembly and filter frames, and dimensions, motor locations and electrical characteristics and connection requirements.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.

- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 OPERATION AND MAINTENANCE DATA (REFER TO SECTION 230500)

- A. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.

1.7 EXTRA MATERIALS (REFER TO SECTION 230500)

- A. In addition to the filters required for operating the equipment, provide an extra set of filters for each piece of equipment.

1.8 QUALITY ASSURANCE

- A. Provide all filters as product of one manufacturer.
- B. Assemble filter components to form filter banks from products of one manufacturer.
- C. Filter access shall be designed so filter can be replaced without use of tools.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Manufacturers (Refer to Section 230500):
 - 1. Farr
 - 2. Cambridge
 - 3. American Air Filter

2.2 DISPOSABLE, EXTENDED AREA PANEL FILTERS (MERV 8)

- A. UL 900 Class 2 media, pleated, lofted, non-woven, reinforced cotton and synthetic fabric, supported and bonded to welded wire grid; rigid, heavy duty frame, high wet strength beverage board ASHRAE 52 rated; 25 to 30 % dust spot efficiency; 90 to 92 % weight arrestance.
- B. Basis of Design: Farr 30/30.

2.3 DISPOSABLE, EXTENDED AREA PANEL FILTERS (MERV 13)

- A. UL 900 Class 2 media, pleated, lofted, non-woven, reinforced cotton and synthetic fabric, supported and bonded to welded wire grid; rigid, heavy duty frame, high wet strength beverage board ASHRAE 52 rated; 80 % to 85 % dust spot efficiency. Merv 13
 - 1. 4" thick (type 2b), 0.35" APD at 500 FPM (clean)
- B. Basis of Design: Camfil Farr AP-Thirteen.

2.4 FILTER GAUGES

- A. Manufacturers: (Refer to Section 230500)
 - 1. Dwyer series 2000, Magnahelic.
- B. Direct Reading Dial: 3½ inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0 to 2.0 inches WG, 2 % of full scale accuracy.
- C. Accessories: Static pressure tips with integral compression fittings, ¼ inch tubing, 2-way or 3-way vent valves.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide air cleaning devices in accordance with manufacturer's instructions and as indicated.
- B. Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.
- D. Refer to Section 230500 for filters for temporary heating and ventilating. Filters shall not be less than Farr 30/30.
- E. Provide filter gauges on filter banks at all air handling units installed with separate static pressure tips upstream and downstream of filters.

END OF SECTION 23 4000

SECTION 23 6213 - PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Condensing unit package
- B. Charge of refrigerant and oil
- C. Controls and control connections
- D. Refrigerant piping connections
- E. Motor starters
- F. Electrical power connections

1.2 RELATED SECTIONS

- A. Section 23 05 00 – Common Work Results for HVAC
- B. Section 23 05 13 – Common Motor Requirements for HVAC Equipment
- C. Section 23 05 48 – Vibration Controls for HVAC
- D. Section 23 05 49 – Seismic Controls for HVAC
- E. Section 23 23 00 – Refrigerant Piping
- F. Section 23 73 00 – Indoor Central Station Air Handling Units
- G. Section 23 82 00 – Convection Heating and Cooling Units

1.3 REFERENCES

- A. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment
- B. ARI 270 - Sound Rating of Outdoor Unitary Equipment
- C. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units
- D. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units
- E. ASHRAE 15 - Safety Code for Mechanical Refrigeration
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

- G. NEMA MG1 - Motors and Generators
- H. UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical
- I. UL 303 - Refrigeration and Air-Conditioning Condensing, and Air-Source Heat Pump Equipment

1.4 DESCRIPTION

- A. The owner will issue a separate contract for the Air Handler, Spare Parts, and Factory Startup as specified herein. The Air Handler, Spare Parts, and Factory Startup will be provided as specified herein. The Contractor shall omit the Air Handler, Spare Parts, and Factory Startup as specified in this section from the bid, but shall include any required interfaces with the equipment supplier and installation as outlined herein, and as outlined on the drawings and specifications.

1.5 SUBMITTALS FOR REVIEW

- A. Submit under provisions of Section 23 05 00.
- B. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams. Performance ratings shall be matched with indoor equipment to ensure capacities are complementary.

1.6 SUBMITTALS AT PROJECT CLOSEOUT (REFER TO SECTION 23 05 00)

- A. Operation and Maintenance Data: Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.7 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection:
 - 1. Condensing Units shall be ETL or UL listed and shall carry the ETL or UL Label.
- B. Electrical connection points (lugs) shall be UL listed for use with both copper and aluminum wiring.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Section 23 05 00 - Product delivery, storage and handling
- B. Accept products on-site in factory-fabricated protective containers. Inspect for damage.
- C. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

- D. Handle carefully to avoid damage to components, enclosures and finish. Protect coils.

1.9 EXTRA MATERIALS (REFER TO SECTION 23 05 00)

- A. Provide complete change of lubricating oil.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers (Refer to Section 23 05 00):

- 1. Daikin

2.2 GENERAL DESCRIPTION

- A. Each unit shall be specifically design for outdoor condensing unit application and include weatherproof cabinet.
- B. Furnish unit configuration, layout, performance and electrical characteristics as shown on project plans and schedule.
- C. The unit shall undergo an operational test prior to shipment. The factory test shall include a refrigeration circuit check test, a unit safety control system operations checkout, and a final unit inspection.
- D. The complete unit shall be ETL listed.
- E. Unit shall be completely factory assembled and shipped in one piece.
- F. This unit to be shipped with nitrogen holding charge.
- G. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
- H. Performance: All scheduled capacities and face areas are the minimum accepted value. All scheduled amps, KW, and HP are maximum accepted values that allow scheduled capacity to be met

2.3 CABINET

- A. Exterior surfaces shall be constructed of painted galvanized steel, for aesthetics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment

and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16" at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings.

- B. Access shall be provided to compressors and electrical and controls components.
- C. The unit base frame shall be constructed of 13 gauge pre-painted steel to prevent base rail corrosion.
- D. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

2.4 CONDENSER SECTION

- A. All Units shall provide the Energy Efficiency specified EER and IEER per the schedule equipment or higher.
- B. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
- C. Condenser coils shall be an all aluminum design, and mounted on polymer brackets, to minimize di-electric corrosion. The aluminum tube shall be a micro channel design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond. Each condenser coil shall be factory leak tested with high-pressure air under water.
- D. Head Pressure Control
 - 1. Units shall have at least one condenser fan controlled to maintain positive head pressure. SpeedTrol™ condenser fan speed control shall be added to the last fan off on each refrigeration circuit to provide cooling operation to ambient temperatures down to 0° F. Fan speed control shall be field adjustable.
- E. Each unit shall have two independent refrigeration circuits for redundancy. Each circuit shall be complete with a low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with Refrigerant R32 and oil.
- F. Each unit shall have at least 4 compressor stages of cooling capacity control for better part load control as required by ASHRAE 90.1-2013. Each circuit shall have a variable speed compressor for maximum efficiency and turndown.

2.5 FANS AND MOTORS (REFER TO SECTION 23 05 13)

- A. Vertical discharge direct driven propeller type condenser fans with fan guard on discharge.
- B. Weatherproof motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection.
- C. Motors as indicated.

2.6 REFRIGERANT CIRCUIT

- A. Provide each unit with two (2) independent refrigerant circuits, factory supplied and piped. Refer to Section 23 23 00.
- B. For each refrigerant circuit, provide as the manufacturer requires:
 - 1. Filter dryer replaceable core type
 - 2. Liquid line sight glass and moisture indicator
 - 3. Hard shut-off thermal expansion valve kit for maximum operating pressure
 - 4. Insulated suction line
 - 5. Suction and liquid line service valves and gauge ports
 - 6. Charging valve
 - 7. Discharge line check valve
 - 8. Compressor discharge service valve
 - 9. Condenser pressure relief valve
 - 10. Compressor start assist
 - 11. Crankcase heater
 - 12. Cycle protector
 - 13. Time delay relay
 - 14. High pressure switch
 - 15. Low pressure switch

2.7 CONTROLS

- A. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, factory wired with single point power connection.
- B. For each compressor, provide across-the-line winding starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay
- C. Each unit shall be equipped with a complete MicroTech® microprocessor-based control system. The unit control system shall include all required temperature and pressure sensors, input/output boards, main microprocessor and operator interface. All boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted, wired and tested.

- D. The microprocessor shall be a stand-alone DDC controller not dependent on communications with any on-site or remote PC or master control panel. The microprocessor shall maintain existing set points and operate standalone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures.
- E. The main microprocessor should support an RS-232 direct connection to a product service tool or modem. A communications module shall be provided for direct communication with the BAS network.
- F. All digital inputs and outputs shall be protected against damage from transients or wrong voltages. Each digital input and digital output shall be equipped with an LED for ease of service. All field wiring shall be terminated at a separate, clearly marked terminal strip.
- G. The paired air handler shall be provided with a refrigerant detection system. See 237300.

2.8 PERFORMANCE

- A. See schedules on drawings for capacities.

2.9 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. See schedules on drawings for electrical requirements.

2.10 WARRANTY

- A. The manufacturer shall provide 12 month parts and labor warranty followed by a 4 year compressor parts only warranty. Defective parts will be repaired or replaced during the warranty period at no charge. The warranty period shall commence at start up, or 6 months after shipment, whichever occurs first.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's installation instructions.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.
- C. Provide for connection to electrical service. Refer to Division 26.
- D. Provide vibration and seismic controls in accordance with 23 05 48
- E. Install units on existing roof curb on post supports. See structural plans.

- F. Provide connection to refrigeration piping system and evaporators. Refer to Section 23 23 00. Comply with ASHRAE 15.
- G. Furnish charge of refrigerant and oil.
- H. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.
- I. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.
- J. Provide cooling season start-up, and winter season shut-down for first year of operation.

3.2 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 6213

SECTION 23 7300 - CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Custom Air Handling Units (Air Handling Units on Mechanical Equipment Schedules)

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230513 – Common Motor Requirements for HVAC Equipment
- C. Section 230548 – Vibration Isolation
- D. Section 230549 – Seismic Controls for Mechanical
- E. Section 230593 – Testing, Adjusting, and Balancing
- F. Section 230923 – Direct-Digital Control for HVAC
- G. Section 230995 – Variable Frequency Drives
- H. Section 232113 – Hydronic Piping
- I. Section 232116 – Hydronic Piping Specialties
- J. Section 232500 – HVAC Water Treatment
- K. Section 234000 – Air Cleaning Devices

1.3 REFERENCES

- A. ANSI/AFBMA9 - Load Ratings and Fatigue Life for Ball Bearings
- B. AMCA/ANSI Standard 204: Balance Quality and Vibration Levels for Fans
- C. AMCA 99 - Standards Handbook
- D. AMCA 210 - Laboratory Methods of Testing Fans for Rating
- E. AMCA 300 - Test code for Sound Rating Air Moving Devices
- F. AMCA 301 - Methods of Publishing Sound Ratings for Air Moving Devices
- G. AMCA 320: Laboratory Method for Sound Testing of Fans Using Sound Intensity

- H. AMCA 500 - Test Methods for Louvers, Dampers and Shutters
- I. ARI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
- J. ARI 435 - Standard for Application of Central-Station Air-Handling Units
- K. NEMA MG1 - Motors and Generators
- L. NFPA 70 - National Electrical Code
- M. UL 1995 - Standard for Safety - Heating and Cooling Equipment
- N. UL 508 - Standard for Industrial Control Panels

1.4 DESCRIPTION

- A. The owner will issue a separate contract for the Air Handler, Spare Parts, and Factory Startup as specified herein. The Air Handler, Spare Parts, and Factory Startup will be provided as specified herein. The Contractor shall omit the Air Handler, Spare Parts, and Factory Startup as specified in this section from the bid, but shall include any required interfaces with the equipment supplier and installation as outlined herein, and as outlined on the drawings and specifications.

1.5 SUBMITTALS FOR REVIEW (REFER TO SECTION 230500)

- A. General
 - 1. Statement of Conformance: The air handling unit submittal shall be accompanied by a statement of conformance by the air handling unit supplier. This statement of conformance shall indicate that the air handling units, as installed, will meet all of the requirements of these specifications. If the air handling units will not meet each requirement of these specifications, this statement of compliance shall indicate each individual requirement that cannot be met, the impact this might have on the system, and the proposed method of equivalent compliance.
 - 2. Indicate weights, fan performance, coil capacities, ratings, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 3. Dimensioned plan and elevation view drawings and location of all field duct connections and openings.
 - 4. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 - 5. Unit Manufacturer shall provide certified ratings conforming to the latest edition of AMCA 210, 300, 500, and AHRI 410.
 - 6. Testing: Provide testing procedures to be performed in accordance with these specifications. When field testing is required, provide the name of the testing agency(ies) to be utilized.
 - 7. Construction: Detail side and roof panel, base, floor, and filter rack construction as well as finish.
 - 8. Access Doors: Indicate construction, method of sealing, and safety lockout features. Indicate doors to be provided with safety lockouts and direction of swing of each door.

9. Control Dampers: Detail damper construction including blade type and frame, blade, and seal material. Provide leakage data.
 10. Factory Installed Components: Indicate factory installation of actuators as required.
 11. The equipment Manufacturer shall furnish calculations showing the estimated sound power levels at the supply air connection, return air connection, outside air opening, relief air openings, as well as unit casing radiation for each air conditioning unit. Sound power levels shall be determined for each octave band and shall not exceed the levels listed in the equipment schedule in the drawings. See schedule on drawings for Basis of Design.
- B. Electrical
1. Indicate motor sizes and electrical characteristics.
 2. Lights/Wiring: Indicate number, location, and type of lights as well as conduit and wire routing and point of connection. Clearly indicate factory installed and field installed wiring.
 3. Disconnect enclosure shall be mounted in accordance with the requirements of the NEC for access height above the roof and shall not exceed 6 feet above the finished roof, floor, or access platform, as applicable.
- C. Fans
1. Construction: Indicate type, material, blade type, class, shaft material and type of attachment to wheel and sheaves, base construction, safety screen and belt guard construction, seismic and fan thrust restraint and vibration isolation provisions. Detail flow measurement station when required.
 2. Performance Information: Provide all information indicated in the equipment schedule. Performance shall be based on the design external static pressure plus the internal static pressure of the unit as submitted for the design airflow. For fan array provide fan performance for all fans operating and one fan failed.
 3. Fan Curves: Provide certified fan curves for each fan with design flow and pressure plotted. Curves shall be provided on a chart with flow on the x-axis and pressure on the y-axis. Brake horsepower shall be indicated on the chart sufficient to determine the brake horsepower at any given point on the curve.
- D. Coils
1. Construction: Indicate casing, tube, fin, header, and rack construction, including tube diameter and fin spacing. Indicate coils are fully drainable and show vents and drains (excluding refrigerant coils).
 2. Performance Information: Provide all information indicated in the equipment schedule.
- E. Condensate Drain Pans: Indicate material, double-sloped construction, fully drainable nature, pitch of slope, location and coverage, and drain connection size and location.
- F. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- G. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 OPERATION AND MAINTENANCE MATERIALS (REFER TO SECTION 230500)

- A. Provide the following minimum information: Fan and coil performance; fan curve information (for fan array provide fan performance for all fans operating and one fan failed); lubrication instructions including lubrication points, type of lubrication to be provided, and frequency of lubrication; instructions for filter, motor and drive replacement; wiring diagrams; customized spare parts list for each air handling unit with unit tag #, serial #, OEM part #/description for motor, coil, filters, filter gauges, bearings, drives, sheaves, fan shaft, belts and other commodity components.
- B. Section 230500 - Project Finalization: - Operation and Maintenance Manual.
- C. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- D. Include customized Parts list with tag number, serial number, OEMs' part number/description for motor, coil, filters, filter gauges, bearings, drives, sheaves, fan shaft, belts and other commodity components.

1.7 REGULATORY REQUIREMENTS

- A. Air handling units shall be designed and manufactured in strict accordance with UL 1995 Standard for Air Handling Equipment. Air handling unit shall be ETL or UL listed in accordance with UL 1995, and shall bear the ETL or UL label. If the manufacturer cannot provide an ETL/UL sticker on the air handling equipment, it shall be the sole responsibility of the contractor to arrange for local, on-site, ETL or UL approval and labeling.
- B. Air handling units with factory wiring shall be factory UL or ETL approved and labeled. If the manufacturer cannot provide an ETL/UL sticker on the air handling equipment, it shall be the sole responsibility of the contractor to arrange for local, on-site, ETL or UL approval and labeling.
- C. Air handling units with electrical panels shall be built in strict accordance to NEC standards and shall bear an appropriate label certifying compliance with UL Standard 508A.
- D. Fan performance ratings shall be AMCA certified in accordance with AMCA 210. Fans shall bear the AMCA sticker.
- E. Sound ratings shall be AMCA certified in accordance with AMCA 300.
- F. Coil capacities, pressure drops, and selection procedures shall be ARI certified in accordance with ARI 410.
- G. Fabrication shall conform to AMCA 99 and ARI 435.

1.8 QUALITY ASSURANCE/QUALIFICATIONS

- A. The air handling unit manufacturer shall provide single source responsibility for all components of the unit whether specifically manufactured by the unit manufacturer or obtained outside and installed in the equipment.
- B. Air handling units and major components shall be products of manufacturing firms regularly engaged in production of such equipment whose products have been in satisfactory use in similar service for not less than ten (10) years.
- C. Units shall be constructed for stable operation (without excessive vibration and surging) with inlet and outlet plenums engineered by the manufacturer. The manufacturer shall consider the duct connection locations as well as the external ductwork and associated velocities that attach to the unit.
- D. The air handling unit shall be shipped to the job site in one piece.
 - 1. Exceptions:
 - a. Air handling units too large to be legally shipped by truck may be shipped to the site in sections.
 - b. Air handling units may be shipped in sections at the contractor's option with written approval from the engineer.
- E. If Manufacturer cannot provide any of the items or options listed within this specification it must be noted as an exception on the bid.

1.9 EFFICIENCY STANDARDS

- A. Units that require a 10 % or greater increase in fan brake horsepower than the scheduled equipment to meet the design flow and external static pressure requirements will not be considered equal and will not be accepted.

1.10 TESTING

- A. The following tests shall be conducted at the fan manufacturer's facility prior to shipping the fans to the air handling unit manufacturer. Test results shall be submitted to the mechanical engineer for review.
 - 1. Vibration: A factory balance test shall be performed on each fan assembly to certify that the fan meets acceptable vibration criteria. Vibration measurements shall be taken in three orthogonal directions: parallel to the shaft in the horizontal plane, perpendicular to the shaft in the horizontal plane, and perpendicular to the shaft in the vertical plane. The values shall be checked with the levels being measured in mils peak to peak. During balancing, the fan shall be tested at the design RPM. The tests shall verify that the unit complies with the following maximum allowable vibration values:

- a. Direct Driven: Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-3, to meet or exceed an equivalent Grade G6.3.

1.11 DELIVERY, STORAGE, AND HANDLING (REFER TO SECTION 230500)

- A. Deliver, store and handle in accordance with the manufacturer's requirements.
- B. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- D. Do not allow unit internal insulation to become wet.

1.12 ENVIRONMENTAL REQUIREMENTS

- A. Do not operate units until both the space and ductwork are clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.13 EXTRA MATERIALS (REFER TO SECTION 230500)

- A. Section 230500, "Project Finalization":
 - 1. Supply one set of filters in addition to the set furnished at the time of substantial completion, see section 23 40 00 for specific filter requirements.
 - 2. Supply two spare return and two spare supply ECM fans.

1.14 DRAWING SCHEDULES

- A. Refer to equipment schedules on drawings for additional information.

PART 2 - PRODUCTS

2.1 GENERAL AIR HANDLING UNIT CONSTRUCTION FEATURES:

- A. Fans and Motors
 - 1. Unit Fans - All fans shall meet the air flow performance specified and shall not exceed the brake horsepower or sound power levels specified on the mechanical equipment schedule. Fan performance shall be based on testing and be in accordance with AMCA Standards 210 and 300.
 - 2. Fan inlet and discharge fan guard.
 - 3. Fan Array Arrangement (see air handler schedule for applicable air handlers):

- a. The fan array system shall consist of multiple, ECM, plenum fans constructed per AMCA requirements for the duty specified, (Class II). All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. The fan array technology shall be selected to operate at a system total static pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed.
- b. All motors shall be standard pedestal mounted type attached to frame with resilient mounts. TEFC, T-frame motors selected at the specified operating voltage, 1750 or 3500 RPM, and efficiency as specified or as scheduled elsewhere. All motors shall include shaft grounding means to protect the motor bearings from electrical discharge machining due to stray shaft current. Motors provided with hybrid ceramic bearings, when specified, do not require shaft grounding devices. Each fan/motor assembly shall be statically and dynamically balanced to meet or exceed a balance grade G6.3 per ANSI S2.19. See specification section 230513 for additional motor requirements.
- c. The fan array shall consist of multiple fans and motors, spaced in the airway tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein.
- d. Each fan/motor assembly shall be removable through a 30" wide, free area, access door located on the discharge side of the fan array.
- e. Flow Measurement Stations (one per fan): Fans to be provided with piezometer rings for airflow measuring of individual fans.
- f. Motor controls
 - 1) Factory shall provide a single point electrical connection and disconnect that serves all the fans in the Array (each motor in the Array shall be factory wired to this main disconnect switch in order to provide the ability to shutoff all the fans simultaneously). This shall be provided for each Fan Array (supply/return).
 - 2) The AHU manufacturer shall provide thermal overload protection for each motor in the Fan Array(s).
- g. Multiple Fan (Fan Array) Airflow Measuring Systems:
 - 1) When multiple fans (fan array) are serving a common duct, the air handling manufacturer shall provide airflow measurement pressure taps for each individual fan and shall provide the factory determined flow coefficient for the fans being furnished. The unit manufacturer shall furnish and install a fan array airflow totalizing system which monitors the airflow capacity of each individual fan based on the differential pressure and flow coefficient and shall provide a totalized airflow rate to the BAS for control and monitoring purposes.
 - 2) Fan Array Airflow Totalizing System:
 - a) Basis-of-Design Product: Subject to compliance with requirements, provide Paragon Controls Inc., Model FAATS-1000 or approved equal. Daikin "Premium Controls" is acceptable.

- b) Accuracy: Plus or minus 0.25 percent of full scale including non-linearity, hysteresis, dead band and non-repeatability for each fan in the array.
 - c) Signal Conversion Resolution: 16-bit A/D and 12 bit D/A.
 - d) Output: Field selectable for 4-20 mA, 0-5 VDC or 0-10 VDC.
 - e) Human-Machine-Interface (HMI) Panel: For air volume indication and configuration of the fan array airflow totalizing system. The HMI shall provide continuous on-screen indication of each individual fan's airflow rate and operational status and shall display the totalized airflow rates for each fan array numerically and graphically as a percent of total design flow. The graphic screen shall be configured to match the fan array layout. Individual fan diagnostics via the HMI panel to indicate the measured differential pressure being reported by each individual fan as well as transducer output. Automatic zero and span calibration for each individual differential pressure transducer performed via the HMI.
 - f) HMI shall have diagnostic tools to assist in fan failure indications with yellow (outside 10% of other fans) and red to indicate failure.
 - g) HMI shall graphically show the fan arrangements per their physical mounting in the unit.
 - h) Alarms: Individual fan failure alarms and warning alarms for when an individual fan's airflow rate is either above or below the average for all fans by a programmable percentage value. A failed fan alarm initiated when the airflow rate for an individual fan goes to zero. The fan (or fans) that are in an alarm state shall be shown on the HMI graphics screen in flashing yellow for warning and red for failed.
 - i) Network Communication: For monitoring and control purposes via BACnet-MS/TP Master communication network to the BAS. The network information shall provide individual fan information and remote configuration of all programmable values.
 - j) Enclosure: Indoor Units shall be provided with a NEMA 1 enclosure and outdoor units shall be provided with a NEMA 4X enclosure.
 - k) Remote Panel: For fan array monitoring systems measuring both supply and return fan arrays in a single air handling unit, provide a remote transducer panel to minimize the pneumatic tubing.
 - l) Complete FAATS and OA system measurement shall only require one power and one DDC connection.
- h. Backdraft Dampers
- 1) All fan cells in fan array AHU's shall include an inlet backdraft damper constructed of extruded aluminum frames and blades. Maximum air leakage 2 cfm/sq. ft. at 1.0 inch differential.
 - 2) The purpose of the backdraft dampers is to prevent the recirculation of air in the event a fan is disabled.
 - 3) The system effect of this damper shall be included in the AHU submittal.
 - 4) Motorized dampers are not acceptable.

B. Water Coils

1. General: Counterflow design (except single row); fully drainable with no trapped tubes; drains and vents provided on each coil. Leak tested to 315 psi under water and again after assembly with compressed air to 315 psi.
2. Casing: Minimum 16 gauge galvanized steel; pressed or extruded tube holes; reinforcing rods such that maximum unsupported length is 60 inches; formed face and stacking flanges on all sides; enclose coils with headers and return bends fully contained within casing.
3. Racks for Stacked Coils: Stacked coils shall be mounted on racks to allow individual removal of each coil; galvanized steel angle for heating coils and type 304 stainless steel angle for cooling coils.
4. Mounting: Provide access to both sides of coils. Provide removable panels in unit wall for coil removal. Provide sealing collars at connection penetrations through unit wall.
5. Tubes:
 - a. Heating Coil: 5/8" x 0.020" seamless copper tube; brazed connections; expanded into fin collars to provide a permanent mechanical bond.
 - b. Cooling Coil: 5/8" x 0.020" seamless copper tube; brazed connections; expanded into fin collars to provide a permanent mechanical bond.
6. Fins: Corrugated 0.006" aluminum
7. Headers: Non-ferrous seamless copper; brazed joints.

C. Refrigerant Coils

1. General: Counterflow design (except single row).
2. Casing: Minimum 16 gauge galvanized steel; pressed or extruded tube holes; reinforcing rods such that maximum unsupported length is 60 inches; formed face and stacking flanges on all sides; enclose coils with headers and return bends fully contained within casing.
3. Racks for Stacked Coils: Stacked coils shall be mounted on racks to allow individual removal of each coil; galvanized steel angle for heating coils and type 304 stainless steel angle for cooling coils.
4. Mounting: Provide access to both sides of coils. Provide removable panels in unit wall for coil removal. Provide sealing collars at connection penetrations through unit wall.
5. Tubes: 5/8 inch outside diameter seamless copper tube; brazed connections; expanded into fin collars to provide a permanent mechanical bond.
6. Fins: Corrugated aluminum
7. Distributors: Brass or copper venturi distributor with seamless copper distributor tubes.
8. Headers: Non-ferrous seamless copper; brazed joints.

D. Double-Sloped Condensate Drain Pans

1. General: Double-sloping, IAQ design; fully drainable; in accordance with ASHRAE 62-89 for both positive draining and cleanability; entire drain pan shall be accessible for annual inspection and cleaning; provided for all cooling coils and humidifier sections.
2. Construction: Type 304 stainless steel; minimum 16 gauge; double wall; continuously welded; insulated.

3. Sloping: 1/8 inch per foot; sloped in two (2) directions: downstream from cooling coil and toward drain connection.
4. Coverage: Drain pans shall be of sufficient size for complete capture of condensate. Pan shall extend a minimum of 6 inches beyond the leaving edge of cooling coils. Stacked coils shall be provided with intermediate drain pans, which shall be connected with stainless steel drain lines.
5. Drain Connection: Same material as drain pan; installed below the bottom of the pan to ensure positive condensate drainage; installed below the bottom of the drain pan to ensure positive condensate drainage; MPT drain connections; connections shall be on same side of unit as coil connections unless specified otherwise

2.2 CUSTOM AIR HANDLING UNITS

A. Manufacturers (Refer to Section 230500):

1. Daikin

B. Configuration: Provide air handling units in configurations as shown on the drawings. Various accessories and sections, including fan sections, shall match for a modular installation.

C. Unit Construction:

1. Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.
2. Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.
 - a. Exterior surfaces shall be constructed of painted galvanized steel, for aesthetics and long-term durability. Paint finish will include a base primer with a high-quality polyester resin topcoat. Finished, unabraded panel surfaces shall be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours exposure. Finished, abraded surfaces shall be tested per ASTM D1654, having a mean scribe creepage not exceeding 1/16" at 1,000 hours minimum exposure to an ASTM B117 salt spray environment. Measurements of results shall be quantified using ASTM D1654 in conjunction with ASTM D610 and ASTM D714 to evaluate blister and rust ratings
 - b. The inner liner shall be constructed of G90 galvanized steel.
 - c. The floor plate shall be furnished with 0.044 inch thick aluminum tread plate.
 - d. Unit will be furnished with solid inner liners.
3. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.
4. The casing leakage rate shall not exceed 0.50 cfm per square foot of casing surface area at design static pressure up to a maximum of +5" w.c. in positive pressure sections and -

- 6" w.c. in negative pressure sections (.0025 m3/s per square meter of cabinet area at 1.24 kPa static pressure)
5. Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.
 6. Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.
 7. Provide cross broke roof cap system to divert water from the top surface of the air handler. The rain shed roof cap shall have 2" standing seams covered with splice cap channels to seal top seam. Splice cap shall break down over sides of standing seam to protect the ends of the seam.
 - a. Rooftop air handler cooling coil piping shall extend through the unit casing for field connection. The installing contractor shall insure that connecting piping is protected from weather.
 8. The unit shall be equipped with a unitized base and shall overhang the roof curb for positive water runoff and shall seat on the roof curb gasket to provide a positive, weather tight seal. Lifting brackets shall be provided on the unit base to accept cable or chain hooks for rigging the equipment.
 9. Roof curb shall be furnished by others. It shall be designed to allow for proper structural support and condensate trapping.
 10. Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall be a minimum of 3" above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2" thickness of insulation under drain pan.
- D. Painting:
1. Panels (wall and roof): Polyurethane primer and polyester hybrid semi-gloss top coat, or etch bond primer and alkyd enamel top coat. All panels shall be primed and top coated on both sides. Paint system shall offer excellent color retention, low fade characteristics, excellent UV resistance, very good resistance to solvents, chemical fumes, acids and alkalis, and very good abrasion resistance. Paint system shall pass a minimum of 1000 hour salt spray test per ASTM B-117. Test documentation shall be available upon request.
 - a. Color: Grey
 2. Uncoated steel: All uncoated steel, including entire base structure, fan assembly (except wheel) and interior racks shall be painted to the same requirements of the panels.
- E. Filter Racks:

1. General: Factory fabricated as an integral part of the air handling unit; multi-stage filter housing or single stage filter housing as required. Filter racks shall accommodate filtration requirements for this project as specified in Section 234000.
 2. Construction: Minimum 16 gauge galvanized steel; gasketed with positive sealing fasteners.
 3. Access/Loading: Face and rear loading for filter sections provided with 24 inches or greater access plenums; side access for all other filter sections.
 4. Differential Pressure: Dwyer 2000 magnahelic or equal differential pressure gauges; ± 2 % accuracy from 0 to 2 inches WG; provide one gauge for each filter stage; gauges mounted on unit exterior; auxiliary taps for each gauge provided for use of Section 230923. Coordinate with Section 230923 for requirements.
 5. Leakage: Leakage at rated airflow, upstream to downstream of filter, holding frame, and slide mechanism shall be less than 1 % at 3 inches WG differential pressure.
 6. Provide filters in accordance with the requirements of Section 234000.
- F. Control Dampers:
1. General: Low-leak, airfoil design; extruded aluminum; parallel blade for return air applications and opposed blade for outside and exhaust air applications or as indicated on the drawings.
 2. Construction: Extruded aluminum hat channel frame, 0.125 inch minimum thickness; extruded aluminum, airfoil blades with integral structural reinforcing entire length of blade.; extruded vinyl double edge blade seals, easily replaceable; non-corrosive molded synthetic bearings; square or hexagonal axles for positive locking - round is not acceptable; linkage concealed in frame.
 3. Leakage: AMCA certified for leakage of equal to or less than 3 CFM/foot² at 1 inch WG of differential pressure at 12×12 inch damper size.
 4. Basis of Design: Ruskin CD-50, Greenheck VCD-43, or approved equal.
 5. Outside air dampers shall be opposed blade type. For other dampers, see manufacturers recommendations.
 6. Damper Linkages and Actuators: All required damper linkages shall be factory installed by the air handling unit manufacturer. Actuators shall be furnished by Section 230923 and field installed. Coordinate with Section 230923 for actuator manufacturer, quantity, type and size as well as damper linkage requirements.
- G. Lights/Wiring:
1. General: LED, vapor-proof, marine type fixtures; protective metal cage and sealed glass enclosure. Provide in each accessible section.
 - a. Units shall be provided fully factory wired per the requirements of this section.
 - b. Units shall be ETL listed to the Standard for Safety for Heating and Cooling Equipment, ANSI/UL Standard 1995 and CAN/CSA C22.2 No. 236-05. Factory wiring practices, safety provisions, components, and labeling shall be per the requirements of the ETL listing.
 - c. All major electrical components shall be UL listed.
 2. Wiring: All lights factory wired to a single switch on the exterior of the unit adjacent to supply fan door; all wiring shall be in conduit and internal to the unit. No external

conduit for lighting shall be allowed. If the unit requires splitting, junction boxes shall be furnished on each section to allow final connections in the field. Wiring shall be clearly labeled to allow ease in final interconnections.

- a. Power wiring shall be enclosed in conduit.
 - b. Ladder wiring diagrams shall be provided. Lines on the diagram shall be numbered, and the associated wires shall be numbered at both terminations for help in troubleshooting
3. Wiring Clearances: Air handling unit manufacturer shall provide a minimum of 1.5 inch clearance above entire width of each interior bulk head (filter, coil, fan, etc.). This will allow wiring 110V or 24V to be run internally and help prevent controls contractor from penetrating exterior panels multiple times with conduit.
- H. Performance: See drawings for unit performance.
- I. Other materials, equipment, and unit performance shall be as specified later in this section or scheduled on the drawings.

2.3 LEAK MITIGATION / REFRIGERANT DETECTION SYSTEM (RDS) FOR COMPRESSORIZED ROOFTOP EQUIPMENT USING A2L REFRIGERANT.

1. Compressorized rooftop equipment using A2L refrigerant shall come equipped with a factory installed Refrigerant Detection System (RDS) in compliance with UL60335-2-40. The factory-installed unit controller will respond and control the unit to comply with UL60335-2-40 according to alarm status of the refrigerant detection system.
2. The Refrigerant Detection System (RDS) shall consist of the following components:
 - a. Dedicated A2L Refrigerant Detection Control Board.
 - b. Refrigerant Sensor(s)
3. Operation and Monitoring:
 - a. The refrigerant sensor or sensors communicate with the refrigerant detection control board. The refrigerant sensors detect the presence of the A2L refrigerant outside of the sealed refrigeration piping and communicate the levels to the refrigerant detection control board. The refrigerant detection controller communicates the RDS status to the factory-installed unit controller.
 - b. Alarm Communications: The unit controller will communicate RDS alarms based on the RDS status in the same way as any other alarm. Alarms are triggered by the following:
 - 1) Refrigerant detected above 15% of the refrigerant lower flammability level (LFL);
 - 2) Refrigerant sensor fault.
 - c. A customer relay is provided for the field to connect directly to the refrigerant detection control board as an alternative means to receive the above two alarm statuses.

- d. Factory unit wiring diagrams must show the refrigerant leak detection system wiring.
4. Equipment including fans & motors shall be rated in accordance with ASHRAE 15 and UL 507 or 705 for the respective refrigerant used.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide air handling units in accordance with the manufacturer's instructions and as indicated on the drawings.
- B. Provide vibration isolation and seismic controls in accordance with Section 230548.
- C. Provide vibration isolation and seismic controls in accordance with Section 230548 and 230549.
 1. Provide neoprene flexible duct connections at each duct connection.
- D. Make all duct and piping connections to units as indicated on the drawings. Piping connections to coils shall be made with unions or flanges.
- E. Pipe all condensate connections line-sized to floor drain. Provide trap of sufficient depth to prevent air bypass.
- F. Install piping and ductwork to allow proper access to unit access doors and to facilitate coil removal.

3.2 MANUFACTURER'S FIELD SERVICES

- A. Supply service of a factory trained representative to supervise on-site testing, start-up and instruction on operation and maintenance to the Owner.
- B. Verify all installation connections and controls.
- C. Field adjust all safety controls.
- D. Field adjust all drive parameters (including acceleration and deceleration ramps and volts-to-hertz ratio for smoother operation).
- E. All mechanical components shall be adjusted for proper alignment.
- F. Submit start-up and test report in accordance with Section 230500.

3.3 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800 and related sections.

END OF SECTION 23 7300

SECTION 23 8126 - SPLIT SYSTEM AIR CONDITIONERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Condensing unit package/indoor fan-evaporator
- B. Charge of refrigerant and oil
- C. Controls and control connections
- D. Refrigerant piping connections
- E. Motor starters
- F. Electrical power connections

1.2 RELATED SECTIONS

- A. Section 230500 – Common Work Results for HVAC
- B. Section 230513 – Common Motor Requirements for HVAC Equipment
- C. Section 230548 – Vibration Isolation
- D. Section 232300 – Refrigerant Piping

1.3 REFERENCES

- A. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment
- B. ARI 270 - Sound Rating of Outdoor Unitary Equipment
- C. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units
- D. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units
- E. ASHRAE 15 - Safety Code for Mechanical Refrigeration
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- G. NEMA MG1 - Motors and Generators
- H. UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical
- I. UL 303 - Refrigeration and Air-Conditioning Condensing, and Air-Source Heat Pump Equipment

1.4 SUBMITTALS FOR REVIEW

- A. Submit under provisions of Section 230500.
- B. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams. Performance ratings shall be matched with indoor equipment to ensure capacities are complementary.
- C. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- D. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 SUBMITTALS AT PROJECT CLOSEOUT (REFER TO SECTION 230500)

- A. Operation and Maintenance Data: Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.

1.6 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection:
 - 1. Condensing Units shall be ETL or UL listed and shall carry the ETL or UL Label.

1.7 DELIVERY, STORAGE, AND PROTECTION

- A. Section 230500 - Product delivery, storage and handling
- B. Accept products on-site in factory-fabricated protective containers. Inspect for damage.
- C. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- D. Handle carefully to avoid damage to components, enclosures and finish. Protect coils.

1.8 EXTRA MATERIALS (REFER TO SECTION 230500)

- A. Provide complete change of lubricating oil.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers (Refer to Section 230500):

1. Daikin
2. Mitsubishi
3. Samsung
4. LG

2.2 SYSTEM DESCRIPTION

- A. The variable capacity cooling only system shall be an Inverter Driven series (cooling only model) split system. The system shall consist of a wall mounted evaporator exclusively matched to outdoor direct expansion (DX), air-cooled, variable speed, inverter driven compressor using R-410A refrigerant. The outdoor unit is a horizontal discharge, variable speed, single fan unit using a single phase power supply. The system shall have a self-diagnostic function, 3-minute time delay mechanism and have a factory pre-charge of R-410A adequate for 33 feet of total length. The system shall have automatic restart capability after a power failure has occurred and a low voltage cut-off feature to prevent stalling during power supply issues.

2.3 QUALITY ASSURANCE

- A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. Each combination shall be rated in accordance with Air Conditioning Refrigeration Institute's (ARI) Standard 210-240 and bear the ARI label.
- D. The outdoor unit will be factory charged for a length of 33 feet of refrigerant with R-32 refrigerant.
- E. A holding charge of dry nitrogen shall be provided in the evaporator.
- F. System efficiency shall meet or exceed 18 SEER.

2.4 INDOOR UNIT

- A. General: The indoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. Both liquid and suction lines must be individually insulated between the outdoor and indoor units.
 1. Unit Cabinet:
 - a. The indoor unit shall have a white, "flat screen" finish.
 - b. The drain and refrigerant piping shall be accessible from six (6) positions for flexible installation (right side, right back, and right bottom; and left side, left back, and left bottom).

- c. The cabinet shall be supplied with a mounting place to be installed onto a wall or ceiling for securely mounting the cabinet, see equipment schedules for indoor unit type.
2. Fan:
 - a. The evaporator fan shall be an assembly consisting of a direct-driven fan by a single motor.
 - b. The fan shall be statically and dynamically balanced and operate on a motor with permanent lubricated bearings.
 - c. An auto-swing louver for adjustable air flow (vertically) is standard via the wireless remote control furnished with each system.
 - d. The indoor fan shall offer a choice of five speeds, plus quiet and auto settings.
3. Filter:
 - a. The return air filter provided will be a mildew proof, removable and washable filter.
4. Coil:
 - a. The evaporator coil shall be a nonferrous, aluminum fin on copper tube heat exchanger.
 - b. All tube joints shall be brazed with silver alloy or phoscopper.
 - c. All coils will be factory pressure tested.
 - d. A condensate pan shall be provided under the coil with a drain connection.
5. Electrical:
 - a. The outdoor unit shall be powered with 208-230 volts, 1 phase, and 60 hertz power. The indoor unit shall receive 208-230 volt, 1 phase, 60 hertz power from the outdoor unit.
 - b. The allowable voltage range shall be 187 volts to 253 volts.
6. Control:
 - a. The unit shall have a backlit, wireless remote infra-red controller capable to operate the system. It shall have Cooling Operation, Dry Operation and Fan Only Operation.
 - b. The controller shall consist of an On/Off Power switch, Mode Selector, Fan Setting, Swing Louver, On/Off Timer Setting, Temperature Adjustment, °C or °F Temperature Display, and Powerful Operation
 - 1) On/Off switch powers the system on or off.
 - 2) Mode selector shall operate the system in cool, fan or dry operation.
 - 3) Fan setting shall provide five fan speeds, plus quiet and auto settings.
 - 4) Swing louver shall adjust the airflow (horizontal and vertical) blades.
 - 5) On/Off timer is used for automatically switching the unit on or off.
 - 6) Temperature adjustment allows for the increase or decrease of the desired temperature.

7) Powerful operation allows quick cool down in the desired space to achieve maximum desired temperature in the shortest allowable time period.

- c. The remote control shall perform Fault Diagnostic functions which may be system related, indoor unit or outdoor unit related depending on the fault code.
- d. Temperature range on the remote control shall be 64°F to 90°F in cooling mode.
- e. The indoor unit microprocessor has the capability to receive and process commands via return air temperature and indoor coil temperature sensors enabled by commands from the remote control.

7. Accessories:

- a. Provide with condensate pump where unit cannot drain by gravity.
- b. Condensate overflow switch
- c. Other items scheduled on drawings

2.5 OUTDOOR UNIT

A. General: The outdoor unit shall be specifically matched to the corresponding indoor unit size. The outdoor unit shall be complete factory assembled and pre-wired with all necessary electronic and refrigerant controls.

1. Unit Cabinet:

- a. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

2. Fan:

- a. The fan shall be a direct drive, propeller type fan.
- b. The motor shall be inverter driven, permanently lubricated type bearings, inherent.
- c. The fan shall be capable of operating in "silent operation" which lowers the outdoor fan speed in cool mode.
- d. A fan guard is provided on the outdoor unit to prevent contact with fan operation.
- e. Airflow shall be horizontal discharge.

3. Coil:

- a. The outdoor coil shall be nonferrous construction with corrugated fin tube.
- b. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.
- c. Refrigerant flow from the condenser will be controlled via a metering device.

4. Compressor:

- a. The compressor shall be an inverter-driven compressor.
- b. The outdoor unit shall have an accumulator and four-way reversing valve.

- c. The compressor shall have an internal thermal overload.
 - d. The outdoor unit can operate with a maximum vertical height difference of 66 feet and overall maximum length of 98 feet without any oil traps or additional components.
5. Electrical:
- a. The electrical power requirement is 208-230 volt, 1-phase, and 60 Hz power.
 - b. The voltage range limitations shall be a minimum of 187 volts and a maximum of 253 volts.
 - c. The outdoor shall be controlled by a microprocessor located in the outdoor and indoor units via commands from the infrared remote controller.
 - d. Dedicated EEV's shall be provided for capacity control during part load of the indoor unit.
6. Provide with low ambient kit capable of operation of -4°F.

2.6 PERFORMANCE

- A. See schedules on drawings for capacities.

2.7 ELECTRICAL CHARACTERISTICS AND COMPONENTS

- A. See schedules on drawings for electrical requirements.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's installation instructions.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.
- C. Provide for connection to electrical service. Refer to Division 26.
- D. Install units on vibration isolation and seismic controls in accordance with Section 230548 / 230549.
- E. Roof mounted: Install on raised support platform provided by others unless indicated otherwise on drawings.
- F. Provide connection to refrigeration piping system and evaporators. Refer to Section 232300. Comply with ASHRAE 15.
- G. Furnish charge of refrigerant and oil.

- H. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.
- I. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.
- J. Provide cooling season start-up, and winter season shut-down for first year of operation.
- K. Pipe condensate to nearest drain with p-trap and indirect waste termination in accordance with the manufacturers requirements.

3.2 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800and related sections.
- C. Provide building commissioning support as specified in Sections, 230800and related sections.

END OF SECTION 23 8126

ELECTRICAL CONTRACT SPECIFICATIONS DIVISIONS 26, 28



7/10/2025

The Engineer's seal and signature affixed hereon is all inclusive for the full content of this portion of the document

SECTION 26 0101 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 CONDITIONS AND REQUIREMENTS

- A. Refer to instructions to bidders, general conditions, and supplementary general conditions of these specifications that govern work under Division 26. Refer to other sections of these specifications for additional related requirements.

1.2 COORDINATION DRAWINGS

- A. Each subcontractor for Division 26, 28 shall be required to produce coordination drawings for the purposes of multi-disciplinary coordination.
- B. In addition to production of coordination drawings, coordinate work and attend meetings as may be necessary with other subcontractors/trades, resolve conflicts and adjust coordination drawings as required.
- C. Provide minor adjustments and additional work necessary at no increase in Contract Sum.

1.3 SCOPE OF WORK

- A. The work covered by the electrical section (Division 26) of the specifications shall include:
 - 1. Furnishing materials and supplying labor, equipment and services to install the electrical systems as shown on the accompanying drawings and specified herein.
 - 2. Testing and adjusting of the completed electrical systems in the manner described herein.

1.4 CODES, PERMITS AND FEES

- A. Electrical work shall be in complete accordance with the latest revised edition of the following:
 - 1. National Electrical Code
 - 2. International Building Code
 - 3. International Mechanical Code
 - 4. International Fire Code
 - 5. Americans with Disabilities Act
 - 6. Electrical Safety Orders of the State Department of Labor and Industries
 - 7. Regulations of the State Fire Marshal
 - 8. Regulations of the State Board of Fire Underwriters
 - 9. Requirements of Washington State Industrial Safety and Health Administration (WISHA)
 - 10. Washington Administrative Code

11. Applicable sections of other State and local codes

- B. In case of differences between building codes, state laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Promptly notify Owner's Representative in writing of such differences.
- C. The Contractor, at their expense, shall obtain permits and inspections required for the electrical work on this project. Inspection certificates shall be included in the Operation and Maintenance Manuals. Deliver copies thereof to the Owner prior to final acceptance of the work.
- D. Pay costs levied by CWU and/or governing agencies associated with electrical service, telephone service, and cable TV service connections and include these costs within the bid. This shall include but not limited to tap fees, service mains, meter and vault charges, etc.
- E. Comply with serving company regulations.

1.5 INTENT AND INTERPRETATIONS

- A. It is the intent of these specifications and the accompanying drawings to result in a complete electrical installation in complete accordance with all applicable codes and ordinances.
- B. The drawings and specifications are intended to supplement each other and details contained in one and not the other shall be included as if contained in both. Items not specifically mentioned in the specifications or noted on the drawings, but which are necessary to properly complete the installation of the indicated systems or to render the systems operational, shall be provided, unless specifically excluded.
- C. In the event that discrepancies exist, or that required items or details have been omitted, notify the Owner in writing of such discrepancy or omission at least five (5) days prior to bid date. Failure to do so shall be construed as the willingness to supply necessary materials and labor required for the proper completion of this work.

1.6 DEFINITIONS

- A. The term "The Contractor", when used in Division 26 of the specifications, shall be construed to mean the Contractor for the electrical work.
- B. The term "Electrical Systems Installer", where used in Division 26 of the specifications, refers to the firm, licensed by the State to perform electrical installation, which is responsible for immediate supervision of electrical work on the project.
- C. The word "provide", where used in this specification and on the accompanying drawings, shall mean furnish and install.

1.7 DRAWINGS

- A. The Electrical Drawings shall serve as the working drawings for the electrical work, but the Mechanical Drawings shall take precedence over the Electrical Drawings if dimensional discrepancies exist. The Electrical Systems Installer shall review the plans for the work of the other trades and shall adjust their work to conform to the conditions indicated thereon.
- B. Work covered under Division 26 has been indicated on the drawings in locations that should allow installation without interfering with the work of other trades; however, exact finish locations have not been indicated. Therefore, locations of work and equipment shall be verified to avoid interferences, preserve headroom, provide access for maintenance and keep openings and passageways clear. Changes shall be made in locations of equipment and materials as required to accomplish these purposes without additional claims or charges.
- C. The locations of existing concealed lines and connection points have been indicated as closely as possible from available information. Assume that such connection points are within a 10 foot radius of the indicated location. Where connection points are not within this radius, contact the Owner for a decision before proceeding or proceed at risk of cost.
- D. At the beginning of the work, set aside one complete set of the drawings which shall be maintained as a complete Record Drawings set. Notations shall be done in a neat and legible manner and in accordance with the Owner's instructions.
 - 1. The record drawings shall be updated daily by the foreman to show changes from the original drawings and the exact locations, sizes and kinds of equipment. This set of drawings shall not be used for other purposes and shall be maintained at the job site and available for review.
 - 2. Record drawings shall indicate actual size of electrical equipment routing of major raceway systems and location of control devices.
 - 3. The actual location and elevation of buried lines, boxes, monuments, stub-outs and other provisions for future connection shall be shown on the record drawings and shall be referenced to the building lines or approved bench marks.
 - 4. Upon completion of the job, deliver the marked-up record drawings to the Owner.
- E. By the act of submitting a bid, the Contractor shall be deemed to have:
 - 1. Examined the site and familiarize themselves with the conditions affecting the work. No additional allowance shall be granted because of lack of knowledge of such conditions.
 - 2. Verified measurements at the building and acquaint themselves with the existing conditions before submitting their bid proposal.
 - 3. Examined mechanical and other applicable drawings.
 - 4. Become familiar with the electrical drawings and specifications.
 - 5. Developed an understanding of the electrical system requirements.
 - 6. Discussed the project with the Electrical System Installer and determine that he can successfully execute the electrical work.
 - 7. Accepted such conditions and included allowances for them in their bid.

1.8 ELECTRICAL COST BREAKDOWN

- A. Furnish to the Owner's Representative a breakdown of the electrical construction cost within thirty (30) days of notice to proceed.
- B. Provide cost breakdown for the categories that follow. The cost breakdown shall include all Division 26 and 28 work. Each category shall identify separate costs for material and labor/installation.
- C. The breakdown shall be in general conformance with the following:
 - 1. Bonds, Permits, Fees
 - 2. Cartage, Rentals, Shack
 - 3. Supervision
 - 4. Branch Circuit Conduit and Wire
 - 5. Devices and Plates
 - 6. Panelboard (Modifications)
 - 7. Disconnects and Miscellaneous Materials
 - 8. Equipment Connections
 - 9. Fire Alarm System (Modifications)

1.9 PAYMENT REQUESTS

- A.
- B. Payment requests for materials and equipment will not be reviewed or approved until shop drawings have been received and approved.

1.10 GUARANTEE

- A. The electrical equipment and installation shall be guaranteed for a period of one (1) year from date of acceptance unless an individual item or specification is otherwise noted as longer. Make good at own expense defects in work, and/or equipment furnished, which shall develop during the one year guarantee period and stand expenses of cutting, patching and repairing made necessary by the corrections of unsatisfactory work or equipment operation.

1.11 ALTERNATES

- A. See Division 23 for a list of alternates to bid for this project. Include in the bid the cost for a complete working electrical system as described in the alternates and shown on the drawings.

1.12 COORDINATION DRAWINGS

- A. Each subcontractor for Division 26 and 28 is required to produce coordination drawings for the purposes of multi-disciplinary coordination as specified in Division 01.

- B. In addition to production of coordination drawings, the subcontractors shall coordinate their work and attend meetings with other subcontractors/trades, resolve conflicts, and adjust coordination drawings as required.
- C. Contractors shall provide minor adjustments and additional work necessary at no increase in Contract Sum.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials used under this Contract, unless specifically noted otherwise shall be delivered to the site new, in their original unbroken packages and shall be of the best quality of their respective kind and shall conform to the latest Standard Specifications of the American Society for Testing Materials, National Electrical Manufacturers' Association, National Board of Fire Underwriters or other appropriate agency. Standard items shall bear the stamp indicating listing by Underwriter's Laboratories, Inc. when such listing is available. Custom-designed items shall be fabricated of UL approved materials.
- B. Throughout these specifications various materials, equipment, apparatus, etc., are specified by manufacturer, brand name, type or catalog number. Such designations are to establish standards of desired quality and construction and shall be the basis of the bid.
- C. Substitutions will be allowed only as herein provided. No substitutions will be permitted without the Owner's written acceptance.
 - 1. Prior acceptance submittals shall be accompanied by a transmittal letter indicating date, project name, product description/type, and deviations from contract documents.
 - 2. Subject to the Owner's discretion certain items may be considered for substitution only after samples have been submitted for review.
- D. Contractors wishing to bid on equipment other than that listed shall obtain prior acceptance of same. Unless prior acceptance (By Addendum) is issued to bidders, the Contractor will be held to furnish items exactly as scheduled and/or specified.
- E. Unauthorized product substitution will be removed from the job site and replaced with the specified item at the Contractor's expense.

2.2 EQUIPMENT/MATERIAL SUBSTITUTIONS

- A. Throughout these specifications and drawings, various materials, equipment, apparatus, etc., are specified or scheduled by manufacturer, brand name, type or catalog number. Such designation is to establish standards of desired quality and construction and shall be the basis of design and the bid.
- B. Substitutions will not be permitted without written approval

- C. Where two or more manufacturer designations are listed in these specifications, choice will be optional except that where more than one manufacturer is listed, and only one manufacturer's catalog number is specified or only one manufacturer scheduled on the drawings (basis of design) that standard of quality, dimensional characteristics, capacities, and construction shall be maintained by materials or equipment supplied by the other manufacturer(s).
- D. If the Division 26 Contractor uses manufacturers other than the basis of design, the Contractor shall be responsible for:
 - 1. Insuring the substituted item will fit the available space while allowing proper maintenance access.
 - 2. Changes required by other Contractors caused by the substituted equipment.
- E. In the event other than specified equipment is used and will not fit job site conditions, assume responsibility for replacement with items indicated as the basis of design.

2.3 OWNER FURNISHED EQUIPMENT AND MATERIALS

- A. Accept and become responsible for Owner furnished equipment and materials. Inspect equipment and materials to determine suitability for installation. Immediately notify the Owner of defects or deficiencies. Failure to so notify the Owner shall mean that the Contractor warrants that equipment and materials are of the proper quantity, design and are free from defects. Properly store equipment and materials.

2.4 SUBMITTALS FOR REVIEW

- A. Shop Drawings
 - 1. Shop drawings, catalog information and material schedules shall be submitted for approval on materials and equipment prior to ordering. This applies to specified material and equipment in Division 26.
 - 2. Provide specific wiring diagrams for equipment requiring electrical or control wiring. Upon approval, copies of these diagrams shall be forwarded to pertinent contractors.
 - 3. Shop drawing submittal shall be the same size as the contract documents and shall show the floorplan scaled at 1/8 inch = 1 foot. Shop drawing shall be generated using a computer aided drafting program; as-built drawings shall be delivered to the Owner. CAD floorplans of the contract documents will be provided by the Owner's representative to the Electrical Contractor in .DWG format only after completion of an "Consent for the Release of Electronic Files" (forwarded by the Owner's representative on request).
- B. Furnish complete shop drawing/catalog data for equipment and materials to be used in the work for review. Allow sufficient time for developing shop drawings, processing and review time so that the installation will not be delayed.

- C. Shop drawings shall be reviewed, approved and stamped by Contractor prior to submitting to Owner's Representative for approval. Submittals without such approval will be returned without review.
- D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal
- F. Submit data in accordance with this section. Data shall be black and white, on 8½×11 inch or 11×17 inch, single, one-sided sheets suitable for copying. Diagrams and drawings larger than 8½×11inch shall be accordion folded to fit in a three ring binder. Drawings and catalog data must be clean, neat copies. FAX material or other poor quality copies will not be acceptable.
- G. Submittals shall be bound in a black 3-ring binder with the project name on the cover. Provide index tabs for each specification section in same order and using same name as appears in the Specifications. Electronic PDF submittals are acceptable for engineer review.
- H. Where choices of options and accessories are available or specified, provide written description of what is to be furnished. If necessary, list page numbers where submitted items are described.
- I. Underline or Arrow applicable data.
- J. If material or equipment is not as specified or submittal is not complete, it will be rejected. Only complete submittal including applicable specification sections will be reviewed.
- K. Catalog data or shop drawings for equipment that are noted as being reviewed shall not supersede Contract Documents.
- L. Review comments shall not relieve Contractor from responsibility for deviations from Contract Documents unless attention has been called to such deviations in writing at time of submission, nor shall they relieve this Contractor from responsibility for errors in items submitted.
- M. Check work described by catalog data with Contract Documents for deviations and errors.
- N. Submit four (4) copies of each shop drawing. The Engineer will retain one stamped copy, one will be provided to the Owner and two stamped and reviewed copies will be returned to the Contractor. The Contractor shall be responsible for distribution of required number of reviewed copies to parties other than the Owner's Representative(s). Electronic PDF submittals are acceptable for engineer review.

PART 3 - EXECUTION

3.1 GENERAL

- A. Workmanship shall be of first quality throughout and shall be in complete accordance with the applicable codes.

3.2 SCHEDULING

- A. The work on this project is phased to suit the requirements of the Owner. During construction, it may be necessary to make temporary connections or installations to accommodate the phased nature of the work. Some work may need to be installed and then reinstalled to satisfy the operational requirements of the Owner. Power changeover for existing loads shall be made in the smallest possible increments with branch circuit by branch circuit re-connection required wherever possible.
- B. The controlling issue governing the work described under Division 26 shall be:
DE-ENERGIZING OF ANY FEEDER, SWITCHBOARD, PANEL, BRANCH CIRCUIT OR OTHER EXISTING ELECTRICAL DEVICE OR ITEM SHALL BE AFFECTED ONLY AFTER NOTIFICATION AND SCHEDULING WITH THE OWNER'S PROJECT COORDINATOR A MINIMUM OF TWO WEEKS PRIOR TO DE-ENERGIZATION.
- C. Prepare written proposed schedules for systems, feeders, panels and branch circuits to be de-energized and submit same to the Owner's Project Coordinator fourteen (14) days in advance of the first schedule item for acceptance. Schedules shall include at least the following:
 - 1. Specific load to be de-energized
 - 2. Proposed date and time to be de-energized and re-energized
 - 3. Backup plan should an emergency occur during the outage period (for critical loads)
- D. Schedules proposed by the Contractor are subject to adjustment by the Owner.
- E. Be advised that the above notification and scheduling requirement may necessitate rescheduling, partial completion and re-connection, overtime work at night or on weekends or delay of the work. Contractor costs incurred due to the above shall be included in the original bid price and shall not be the cause for additional claims or charges to the Owner.

3.3 COORDINATION, INSERTS AND OPENINGS

- A. This installation requires extensive interfacing. It is the responsibility of the Contractor to clarify questions or discrepancies with the Owner and to ascertain and verify installation conditions about which he is unsure prior to commencing work. Further, during the entire construction period, coordinate, verify and confirm that related work by other trades is done in a manner that will not complicate or compound the electrical systems work.
- B. Locations of devices, outlets, fixtures, equipment, etc. as shown on the drawings are approximate unless dimensioned. Exact locations of such items shall be determined by the

Owner's representative or secured from special details and drawings. Ensure that no switches or other electric control devices are mounted such that they are trapped behind opened doors or otherwise rendered inaccessible.

- C. Obtain rough-in and connection dimensions as required for power, control and grounding connections to equipment items that require electrical connection.
- D. Verify the physical dimensions of each item of electrical equipment to fit the available space and promptly notify the Owner/Engineer prior to roughing-in, if conflicts appear. Coordination of equipment to the available space and to the access routes through the construction shall be the Contractor's responsibility.
- E. Provide inserts for hangers, brackets, clamps, etc. as required to support boxes, raceways, cables, fixtures, equipment, etc. Coordinate location and routing to avoid interference with work of other trades. Method of insert placement shall suit the type of construction into which the inserts are to be installed.
- F. Furnish and install sleeves and block-outs required for openings in the structure needed to install the electrical work. The responsibility for proper placement of sleeves and block-outs shall be with the Contractor.
- G. Openings for electrical work shall be carefully caulked or grouted as required. Spare conduits shall be tightly capped and labeled.
- H. Roof and exterior wall penetrations shall be flashed and counter-flashed watertight. Caulking shall be equal to General Electric silicone construction sealants.
- I. Provide fireproofing at penetrations to maintain fire-rating of areas.

3.4 CUTTING AND PATCHING

- A. Cutting of concrete or other building materials shall be avoided where possible. The Contractor shall have a workman present at the pouring of concrete and at the building of masonry that contains electrical work.
- B. Cutting and patching of new and existing construction required for the installation of systems and equipment specified in Division 26 shall be the responsibility of the Division 26 Contractor. Cutting shall be accomplished with masonry saws, drills or similar equipment to provide neat uniform openings.
- C. Patch and repair walls, floors, ceilings, and roof with materials of same quality and appearance as adjacent surfaces unless otherwise shown. Surface finishes shall exactly match existing finishes of same materials. Patching shall meet the approval of the Owner's Representative.
- D. Cutting and patching made necessary to repair defective equipment, defective workmanship or by neglect of this Contractor to properly anticipate their requirements shall be included in Division 26.

- E. Cut carefully to minimize necessity for repairs to existing work. Do not cut beams, columns, or trusses or other structural members without the Owner Representative's written approval.
- F. Cutting, patching, repairing, and replacing pavement, sidewalks, roads, and curbs to permit installation of work specified or indicated under this division is responsibility of Division 26.

3.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Follow manufacturer's directions in delivery, storage, protection, and installation of equipment and materials.
- B. Promptly notify Owner's Representative in writing of conflicts between requirements of Contract Documents and manufacturer's directions and obtain written instructions from Owner's Representative before proceeding with work. Bear expenses arising from correcting deficiencies of work that do not comply with manufacturer's directions or such written instructions from Owner's Representative.
- C. Deliver equipment and material to site and tightly cover and protect against dirt, water, and chemical or mechanical injury but have readily accessible for inspection. Store items subject to moisture damage (such as controls) in a dry, heated space.
- D. Notify Owner of equipment delivery dates, twenty-four (24) hours in advance of delivery.
- E. Be responsible for protection of equipment furnished in this Division from vandalism and weather during the phases of construction. Damaged equipment shall be restored to like new condition or replaced at the Contractor's expense.
- F. Factory painted equipment scratched or marred during shipment or construction shall be restored to original "new" condition. This includes complete repainting if necessary to provide exact paint match.

3.6 PROTECTION AND CLEANING

- A. Provide adequate means for protection and protect material and equipment against damage caused during the progress of the work and until approval by the Owner.
- B. Material and equipment, both when in storage and during construction, shall be covered in such a manner that no finished surfaces will be damaged, marred or splattered with plaster or paint, and electrical conductors, buses and connections, electronic components and moving parts shall be kept clean and dry.
- C. Damaged material or equipment, including face plates of panels and switchboard sections, shall be replaced or refinished by the manufacturer at no additional expense to the Owner.
- D. During the progress of the work, clean up after workers and leave the premises and portions of the building where work is taking place free from debris.

- E. Provide and maintain suitable barriers, protective devices, lights and warning signs where required for protection of the public and employees about the building and site.

3.7 PAINTING

- A. No painting is included in Division 26 except as specifically called for.
- B. Where exposed electrical raceways and equipment are to be painted, schedule work to ensure that such electrical items are installed prior to painting or that items installed afterward are painted later to match the original finishes.
- C. Protect latches on panelboard covers, wiring devices, device faceplates, clocks, and other electrical devices against accidental painting.
- D. Protect nameplates and labels on electrical equipment from being obscured by paint.

3.8 VISITING THE PROJECT SITE

- A. Examine premises and understand the conditions that may affect performance of work of this Division before submitting proposals for this work.
- B. No subsequent allowance for time or money will be considered for consequences related to failure to examine existing site conditions.

3.9 TESTS

- A. See individual specification sections for Testing Requirements.

3.10 PARTICIPATION IN COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Divisions 22, 23, 26 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Divisions 22, 23, 26 and related sections.
- C. Provide building commissioning support as specified in Divisions 22, 23, 26 and related sections.

3.11 COORDINATION DRAWINGS

- A. Participate in coordination process as described in Division 23.

END OF SECTION 26 0101

SECTION 26 0102 - PROJECT FINALIZATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Operation and Maintenance Manual
- B. Operation and Maintenance Training/Startup
- C. Spare Parts/Maintenance Materials
- D. Warranties
- E. Final Cleaning
- F. Record Drawings
- G. Punch List Procedures
- H. Maintenance Services

1.2 RELATED SECTIONS

- A. Section 260101 - Basic Electrical Requirements
- B. Section 260800 – Electrical Systems Commissioning

1.3 OPERATION AND MAINTENANCE MANUAL

- A. Bind Operation and Maintenance Manual for Electrical Systems in a black three-post, hard-backed binder with the job title, date, Engineer, and Contractor names.
 - 1. Provide a master index at the beginning of Manual showing items included. Use plastic index tabs for end section of the Manual.
 - 2. First section shall consist of name, address, and phone number of Mechanical and Electrical Engineers, General Contractor, and Electrical Contractors.
 - 3. Provide a separate section for each section of the specifications. Provide index for each section listing equipment included.
- B. Product literature, catalog cuts, etc. shall be clean copies. FAX or other poor quality prints will not be acceptable.
- C. Submit one (1) copy of Operation and Maintenance Manual to Owner's Representative for review. After this review and final approval of the manuals, prepare two (2) copies of

approved manuals for use during the instruction period. Following instruction period, turn over both copies to the Owner. Electronic PDF submittals are acceptable for engineer review.

- D. In general, the following shall be included in the Operation and Maintenance Manual for each electrical equipment item:
1. List of electrical equipment used indicating name, model, serial number, and name plate data of each item together with number and name associated with each system item as indicated on the drawings.
 2. Manufacturer's maintenance instructions: Instructions shall include name of vendor, installation instructions, parts numbers and lists, operation instructions of equipment, and maintenance and lubrication instructions.
 3. Step-by-step procedure to follow in putting each piece of electrical equipment into operation
 4. Wiring diagram for particular equipment item
 5. Refer to individual specification sections for additional information required to be incorporated into the Operation and Maintenance Manual.
- E. Include the following additional items in the O&M Manual:
1. Summary list of spare equipment parts furnished under this contract
 2. Test Records of feeders, transformers, circuit breakers, telephone/data wiring, etc.
 3. Signed checklist of Instruction Period
 4. Copies of specific product Warranties.
 5. Copies of Startup Reports for:
 - a. Motor Starters
 6. Electrical identification schedules
 7. Copies of manual describing specific maintenance services that will be furnished

1.4 OPERATION AND MAINTENANCE TRAINING/STARTUP

- A. Upon completion of the work, assemble the Electrical Systems Installer and subcontractors together with factory representatives for system start-up and demonstration. These people shall assist in start-up and check out each system and remain at the site until the total electrical system operation is acceptable and understood by the Owner's designated maintenance and/or operation personnel. The Electrical System Installer or a subcontractor or factory representative designated by them shall also give personal instructions on operation and maintenance of the electrical equipment to the Owner's maintenance and/or operation personnel.

- B. To prove acceptance of operation and instruction by the Owner’s representative, prepare a written statement of approval detailing it for their signature. The statement shall read as follows:

“I, the Contractor, together with the Electrical Systems Installer and the associated factory representatives, have started each system and the total electrical system, and have demonstrated their normal operation to the Owner’s representative and have instructed them in the OPERATION AND MAINTENANCE THEREOF.”

 OWNER’S REPRESENTATIVE

 CONTRACTOR

ELECTRICAL SYSTEM	DEMONSTRATED BY/WITNESSED BY	INSTRUCTION TIME ALLOTMENT	DATE
262913 – ENCLOSED MOTOR CONTROLLERS	/	2.0 HRS	
283110 - FIRE ALARM SYSTEMS	/	4.0 HRS	
DEMONSTRATE OPERATION AND INSTRUCT OWNER IN MAINTENANCE OF GENERAL ELECTRICAL SYSTEM	/	4.0 HRS	
WRITTEN GUARANTEE RECEIVED	/		
O&M MANUALS RECEIVED	/		
AS-BUILT DRAWINGS RECEIVED	/		

1.5 SPARE PARTS/MAINTENANCE MATERIALS

- A. Provide summarized list of spare parts that are to be furnished. Incorporate into O&M Manual.
- B. Refer to individual specification sections for spare parts to be furnished under this contract.
- C. Turn spare parts and materials over to Owner.

1.6 WARRANTIES/GUARANTEES

- A. Guarantee work to be free from defects in material and workmanship for a period of one (1) year. See General Conditions for beginning of guarantee period. Make good at own expense defects in the work and/or equipment furnished, which shall develop during the one (1) year guarantee period and shall stand expenses of cutting and patching and repairing made necessary to correct unsatisfactory work or equipment operation.

- B. Manufacturer's warrantee certificates shall be included in the Operation & Maintenance Manuals for equipment that is warranted by the manufacturer for a period greater than one year.

1.7 CLEAN-UP

- A. Clean up equipment, materials, cartons and other debris that is a direct result of the installation of equipment under this contract.
- B. Clean exposed conduits, equipment, and fixtures. Repair damaged finishes and leave everything in working order.
- C. Remove stickers from fixtures and electrical equipment.

1.8 RECORD DRAWINGS

- A. Record differences between electrical work as installed and as shown in Contract Documents, on a set of prints of electrical drawings to be furnished by Owner's Representative. Record locations of each power or lighting homerun branch circuit conduit as installed. Return these prints to Owner's Representative at completion of Project. Notations made on drawings shall be neat and legible. These drawings shall not be used for other purposes.
- B. Refer to individual specification sections for additional requirements.

1.9 PUNCH LIST PROCEDURES

- A. Notify the Owner's Representative in writing when the project is ready for punch lists. After punch lists are complete, written notice must be forwarded to the Owner's Representative requesting final checkout. Additional trips by the Engineer to the site for punch list verification that become necessary due to items on previous punch lists that have not been completed at the time of the final checkout will be billed to the Contractor at normal rate plus travel expenses.
- B. At the time of punch list and final project checkout, the project foreman shall accompany the Engineer and remove coverplates, panel covers and other access panels to allow complete review of the entire electrical systems.

1.10 MAINTENANCE SERVICES

- A. Provide separate manual describing specific maintenance services to be provided as required under specific specification sections.

END OF SECTION 26 0102

SECTION 26 0519 - BUILDING WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Building wire and cable
- B. Wiring connectors and connections

1.2 RELATED SECTIONS

- A. Section 260553 - Electrical Identification
- B. Section 312200 - Earthwork

1.3 REFERENCES

- A. NECA Standard of Installation (National Electrical Contractors Association)
- B. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association)
- C. NFPA 70 - National Electrical Code

1.4 SUBMITTALS FOR REVIEW

- A. Product Data: Submit information covering every type of wire or cable to be provided on the project.

1.5 PROJECT CONDITIONS

- A. Verify that field measurements are as indicated.
- B. Conductor sizes are based on copper.
- C. Wire and cable routing indicated is approximate unless dimensioned.

1.6 COORDINATION

- A. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

- A. Manufacturers: Conductors shall be as manufactured by:
 - 1. American Insulated
 - 2. Cerro
 - 3. Encore
 - 4. Essex
 - 5. Houston
 - 6. Southwire

- B. Wire and cable shall be copper single conductor type with 600 volt insulation, unless otherwise indicated.

- C. Copper conductors shall be soft drawn, minimum 98% conductivity.

- D. Grounding conductors shall be copper, no exceptions.

- E. Interior conductors shall be THWN / THHN or XHHW.

- F. Conductors installed within underslab or underground conduit shall be THWN-2 or XHHW-2.

- G. #14 and smaller wire shall be solid.

- H. #12 wire and larger shall be stranded.

- I. Outer jackets of conductors shall be color coded as follows:
 - 1. 120/208 volt circuits.
 - a. Phase A-Black
 - b. Phase B-Red
 - c. Phase C-Blue
 - d. Neutral-White

 - 2. 277/480 volt circuits
 - a. Phase A-Brown
 - b. Phase B-Orange
 - c. Phase C-Yellow
 - d. Neutral-Gray

 - 3. Insulated ground wires-Green.
 - 4. On large conductors, for which color coded jackets are not available, install bands of adhesive non-fading colored tape or slip-on bands of colored plastic tubing over the cables and wires at their terminations and in the vaults, wireways, junction boxes and

- outlet boxes. In vaults and wireways, install the color coding at each end of the wireway and at approximately 3 foot intervals within the vault or wireway.
5. Materials used for identification shall be colorfast and shall withstand cleaning. Colors used shall be the same as specified for outer jackets.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that mechanical work likely to damage wire and cable has been completed.
- C. Verify that raceway installation is complete and supported.

3.2 INSTALLATION IN RACEWAYS

- A. Wire and cable shall be run in metal raceways, except where plastic conduit has been specifically approved. Pull all conductors into raceway at same time.
- B. Branch circuit runs are shown schematically. Except where exact routing is indicated, branch circuit home runs may be grouped and the actual routing of branch circuit conduits may be determined at the site and properly entered on the As-built drawings.
- C. Conduits installed with multiple branch circuits shall be installed with dedicated neutrals for each individual circuit.
- D. Use stranded conductors for control circuits.
- E. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- F. Where more than three current carrying conductors are installed in a single raceway, the minimum wire size shall be increased to provide allowable load current of 100% of the overcurrent device in accordance with National Electrical Code, Table 310-15(b)(2)(a).
- G. Provide dedicated neutrals for multiwire branch circuits.
- H. Splices shall be made in properly sized junction/pull boxes.
- I. Except where sizes are indicated on the drawings, the following schedule shall be adhered to:

Circuit Overcurrent Device Rating	CONDUCTOR SIZES
20 AMPERES OR LESS	#12
25 OR 30 AMPERES	#10
35 OR 40 AMPERES	#8
45 OR 50 AMPERES	#6

Circuit Overcurrent Device Rating	CONDUCTOR SIZES
60 OR 70 AMPERES	#4
80 OR 90 AMPERES	#2
100 OR 110 AMPERES	#1
125 OR 150 AMPERES	#1/0

- J. Use conductor not smaller than 12 AWG for power and lighting circuits.
- K. Use conductor not smaller than 14 AWG for signal and control circuits, except as indicated.
- L. Use 10 AWG conductors for the entire length of the branch circuit for 20 ampere, 120 volt branch circuits longer than 75 feet.
- M. Use 10 AWG conductors for the entire length of the branch circuit for 20 ampere, 277 volt branch circuits longer than 200 feet.
- N. Use suitable wire pulling lubricant for building wire 4 AWG and larger.
- O. Where ambient temperatures are within 50 °F (10 °C) of the maximum allowable operating temperatures of the insulation of a conductor, provide conductors with insulation of higher temperature rating suitable for the temperature to be encountered.
- P. Identify and color code wire and cable as specified above. Identify each conductor with its panel origin at each junction or pull box.

3.3 WIRING CONNECTIONS AND TERMINATIONS

- A. Where indicated in the drawings, taps of feeders shall be made with termination blocks equal to ILSCO LD Series. Quantity and size of termination ports shall match required conductor quantity and size. Termination blocks shall be mounted in a suitable NEMA 1 gutter or enclosure with removable cover.
- B. The use of wire nuts is restricted to splices in wire #8 and smaller and shall be made with Scotchlok or approved equal. Splices made in conductors larger than #8 shall be made with Compression type connectors, smoothed out with insulating putty, and thoroughly taped with Scotch #33 or approved equal electrical tape.
- C. Clean conductor surfaces before installing lugs and connectors.
- D. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
- E. Terminations shall be crimp compression type, bolted to equipment or set screw terminal types in equipment not suitable for compression connectors. Conductors #12 and smaller shall have eye type compression when termination is to a bolted or screw type terminal block or cabinet.

- F. Re-tighten bolt type connections twenty-four (24) to forty-eight (48) hours after installation and before taping. Bolt type connections to bus-bars shall employ spring loaded Belleville washers.
- G. Cables shall extend between outlets with complete electrical continuity and be without shorts or grounds. Cables shall be uninterrupted and unspliced.
- H. Cables shall be routed so as to maintain a separation of at least 2 feet from heat sources and from ballasts, transformers, dimmers and other sources of electromagnetic interference. Avoid cables in areas where they may be damaged as a result of normal use of the area.
- I. Cable run in ceiling cavities shall not lie upon the ceiling or be supported from ceiling suspension wires or from conduits or pipes, but shall be suspended from the building structural elements using black cable ties.
- J. Care shall be exercised during installation not to damage the cable insulation. Damaged cables shall be removed and replaced.
- K. Stranded conductors shall not be connected directly to wiring device screw terminals. Utilize compression plate at screw terminals on devices.

3.4 PLENUMS

- A. **THIS BUILDING HAS PLENUM SPACES.** Wiring not installed in a raceway, for which any portion is installed in or passes through a plenum space, shall be plenum rated for its entire length. Refer to mechanical drawings for locations of plenum spaces.

END OF SECTION 26 0519

SECTION 26 0520 - EQUIPMENT WIRING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Electrical connections to equipment

1.2 RELATED SECTIONS

- A. Section 260519 - Building Wire and Cable
- B. Section 260530 - Conduit
- C. Section 260532 - Boxes

1.3 REFERENCES

- A. NEMA WD 1 - General Purpose Wiring Devices
- B. NEMA WD 6 - Wiring Devices - Dimensional Requirements
- C. NFPA 70 - National Electrical Code

1.4 SUBMITTALS FOR REVIEW

- A. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.

1.5 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.6 COORDINATION

- A. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
- B. Determine connection locations and requirements.
- C. Sequence rough-in of electrical connections to coordinate with installation of equipment.

- D. Sequence electrical connections to coordinate with start-up of equipment.

PART 2 - PRODUCTS

2.1 CORDS AND CAPS

- A. Manufacturers: Leviton, Bryant, Hubbell, Pass & Seymour, and Arrow-Hart.
- B. Attachment Plug Construction: Conform to NEMA WD 1.
- C. Configuration: NEMA WD 6, UL 498, heavy duty nylon construction with external cord clamp and dead-front construction, with rating and NEMA configuration molded on the device. Match receptacle configuration at outlet provided for equipment.
- D. Cord Construction: NFPA 70, Type SO multi-conductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
- E. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
- J. Provide final connection of equipment items as scheduled. Coordinate work with the equipment supplier/installer.
- K. Obtain dimensioned shop drawings from the equipment suppliers prior to rough-in of branch circuits.
- L. Where equipment requires a cord connection, install a new cord and cap if the one furnished does not match the receptacle provided.
- M. Circuit breaker, feeder and fuse sizes shall be coordinated with the nameplate data on the equipment furnished.
- N. Install motor starters and provide power wiring to motors and controls. Verify that starters include an overload device for each ungrounded conductor and a single, common reset button.
- O. Provide lockable disconnecting safety switches for mechanical equipment and for permanently connected motors, unless the connected equipment is complete with an approved disconnecting means, or is adjacent to another approved means of disconnect for the circuit. Disconnection devices shall be fused safety switches except where manual motor starters or toggle switches are indicated on the plans. Provide fused safety switches with the appropriate type and size of fuses.
- P. Motor and starter wiring shall be done in complete accordance with wiring diagrams provided by the supplier. Provide auxiliary contacts and interface wiring for disconnect installed between a VFD and associated motor load. VFD's shall be wired such that it cannot start while the downstream disconnect is in the off position.
- Q. Check the rotation of three phase motors and reconnect same where necessary to provide the proper direction of rotation as required for the driven unit. Check motor starters for properly sized overload relays and properly sized heaters.
- R. Where indicated on the electrical drawings, provide control and interlock wiring on schedules for motor control centers or separate electrical motor controllers, or elsewhere in the Division 26 of the specifications for electrically-powered equipment.
- S. Provide required relays, wiring and equipment required for fire alarm fan shutdown. Interconnecting controls shall be rated to match starter control voltage.
- T. Receptacles and outlet boxes for electric water coolers shall be concealed within the water cooler enclosure.

END OF SECTION 26 0520

SECTION 26 0526 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Grounding electrodes and conductors
- B. Equipment grounding conductors
- C. Bonding

1.2 REFERENCES

- A. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association)
- B. NFPA 70 - National Electrical Code
- C. WAC 296-46B-250

1.3 SUBMITTALS FOR REVIEW

- A. Submit under provisions of Section 260101.
- B. Product Data: Provide data for grounding connections, and installation details. As a minimum, said drawings shall show the type and location of conductors, fasteners, splices and connectors, and ground terminals. Submittal shall include design criteria and calculations for any deviations from these specifications.

1.4 PROJECT FINALIZATION

- A. Submit under provisions of Section 260102.
- B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- C. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with the manufacturer

1.5 OPERATION AND MAINTENANCE DATA

- A. Project Record Documents: Record actual locations of components.

- B. Certificate of Compliance: Indicate approval of installation by authority having jurisdiction.

1.6 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 CONNECTORS

- A. Materials: Fasteners, splices and connectors shall be specifically selected for the materials to be joined.
- B. Manufacturers:
 - 1. Cable Connectors: Burndy Hyground compression or equal.
 - 2. Pipe Clamp Connectors: Thompson Lightning Protection, Inc. Models #803, #804, and #805, or equal.

2.2 EXOTHERMIC CONNECTIONS

- A. Exothermic fusion welds are not allowed.

2.3 WIRE

- A. Material: Stranded copper

PART 3 - EXECUTION

3.1 GENERAL

- A. Grounding conductors shall be copper - no exceptions.

3.2 DOCUMENTATION

- A. At the completion of the project, drawings shall be updated to as-built status.

END OF SECTION 26 0526

SECTION 26 0530 - CONDUIT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Metal conduit
- B. PVC coated metal conduit
- C. Flexible metal conduit
- D. Liquidtight flexible metal conduit
- E. Electrical metallic tubing
- F. Fittings and conduit bodies

1.2 RELATED SECTIONS

- A. Section 260526 - Grounding and Bonding
- B. Section 260532 - Boxes
- C. Section 260553 - Electrical Identification
- D. Section 262727 - Supporting Devices

1.3 REFERENCES

- A. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated
- B. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated
- C. ANSI C80.5 - Rigid Aluminum Conduit
- D. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
- E. ANSI/NFPA 70 - National Electrical Code
- F. NECA "Standard of Installation"

1.4 DESIGN REQUIREMENTS

- A. Conduit Size: ANSI/NFPA 70

- B. Minimum conduit size shall be $\frac{3}{4}$ " for branch wiring and 1" for home runs on power and lighting circuits.

1.5 SUBMITTALS

- A. Product Data: Provide data for metallic conduit, flexible metal conduit, liquid tight flexible metal conduit, metallic tubing, fittings, conduit bodies, and fire sealants.

1.6 PROJECT RECORD DOCUMENTS

- A. Accurately record actual routing of conduits larger than 1 inch.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle Products to site under provisions of Section 260101.
- B. Accept conduit on site. Inspect for damage.
- C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

1.8 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on drawings.
- B. Verify routing and termination locations of conduit prior to rough-in.
- C. Conduit routing is shown on drawings in approximate locations unless dimensioned. Route as required to complete the wiring system.

PART 2 - PRODUCTS

2.1 METAL CONDUIT

- A. Manufacturers: Allied Tube and Conduit, LTV, Triangle PWC, Western Tube and Conduit, or equal
- B. Rigid Steel Conduit: ANSI C80.1
- C. Fittings and Conduit Bodies: ANSI/NEMA FB 1; Threaded galvanized or cadmium plated steel fittings. Bushings shall have nylon insulated throats

2.2 FLEXIBLE METAL CONDUIT

- A. Manufacturers: AFC, Anamet, Triangle PWC, or equal
- B. Description: Interlocked, galvanized steel construction
- C. Fittings: ANSI/NEMA FB 1: Specifically designed for the purpose. Steel compression connectors and couplings shall be utilized for conduit sized 2" or smaller. Steel set screw fittings shall be utilized for conduit sized 2.5" or larger.

2.3 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Manufacturers: AFC, Anamet, Electriflex, Alflex, or equal
- B. Description: Interlocked, galvanized steel construction with PVC jacket.
- C. Fittings: ANSI/NEMA FB 1: Specifically designed for the purpose

2.4 ELECTRICAL METALLIC TUBING (EMT)

- A. Manufacturers: Allied Tube and Conduit, LTV, Triangle PWC, or equal
- B. Description: ANSI C80.3; galvanized tubing
- C. Fittings and Conduit Bodies: ANSI/NEMA FB 1; Steel compression type with nylon insulated throats on connectors for conduit 2" or smaller. Steel set screw type with nylon insulated throats on connectors for conduit larger than 2".
- D. Color Coding: EMT 2" or smaller in size shall be color coded as follows:
 - 1. Fire Alarm – Red
 - 2. Telecom – blue
 - 3. Power – Silver

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Branch circuit conduit types shall be as follows:
 - 1. Rigid metal conduit for exposed runs up to 4 feet 6 inches above the finished floor in sheltered spaces, for exposed runs subject to the weather, for runs in hazardous locations and for underground or underslab runs.
 - 2. Electrical metallic tubing in non-masonry/concrete walls or above ceilings, and for exposed runs more than 4 feet 6 inches above the finished floor in sheltered spaces, except runs in hazardous locations.

3. Liquid-tight flexible steel conduit for connections to motors and other vibrating equipment in damp and wet areas or where exposed to the weather.
 4. Flexible steel conduit for connections to motors and other vibrating equipment in dry, sheltered areas.
- B. Conduits shall be sized in accordance with the applicable codes except where larger conduits are called for on drawings. Sizes shown on the drawings are based on the use of rigid metal conduit and copper conductors with THW insulation unless noted otherwise.
- C. Do not install feeder or branch circuit conduits in poured concrete or masonry walls or slabs without the Owner's approval.
- D. Conduit penetrations of structural elements or conduits run within masonry walls or slabs shall be approved by the Owner in advance of installation.
- E. Conduits run in masonry shall be placed at least 1 inch from the surface. Care shall be taken to avoid placing conduits where they will be subjected to excessive heat.
- F. Conduit ends shall be capped using standard capped bushings or steel "pennies" and bushings to prevent entrance of foreign materials during construction.
- G. Rigid conduit shall be reamed after threads are cut. Joints shall be cut square and shall butt solidly into couplings. Running threads will not be permitted. Cut ends of EMT shall also be reamed.
- H. Bends in rigid conduit and EMT runs larger than 1¼ inch shall be of factory-made elbows unless otherwise specifically approved. Bends in 1¼ inch and 1 inch runs shall be made in an approved bending machine (or factory made). Hickey bends will not be permitted in conduits larger than ¾ inch. Bends shall not show flattening.
- I. Minimum conduit size: ¾" for branch wiring and 1" for home runs for power and lighting circuits.
- J. The radius of the inner edge curve of any field bend shall not be less than indicated in the following table:

Conduit Size (inches)	Inside Radius (inches)
¾	5
1	6
1¼	8
1½	10
2	12
2½	15
3	18
3½	21
4	24

- K. Provide a #12 AWG copper pull wire or a polyethylene pull rope rated at 250 pounds (minimum) tensile strength in each conduit left empty for future use.
- L. Ground and bond conduit under provisions of Section 260526.
- M. Identify conduit under provisions of Section 260553.
- N. Branch circuit runs are shown schematically. Except where exact routing is indicated, branch circuit home runs may be grouped and the actual routing of branch circuit conduits may be determined at the site and properly entered on the As-built drawings.

3.2 RACEWAY INSTALLATION - SPECIAL REQUIREMENTS FOR DIVISION 28 WORK

- A. Where “conduit”, “raceway”, and/or “conduit system” is referred to in this specification it shall be interpreted as follows:
 - 1. Standard weight galvanized rigid steel conduit underground; less than 36 inches above the floor in concrete or masonry walls; and where exposed.
 - 2. Electrical metallic tubing above ceilings and higher than 36 inches above the floor in frame walls.
 - 3. Cable tray shall be used where indicated on the drawings.
NOTE: ONLY METALLIC CONDUIT SHALL BE USED FOR THE DIVISION 28 RACEWAY SYSTEM. PVC CONDUIT WILL NOT BE ALLOWED.
- B. Minimum conduit size is $\frac{3}{4}$ inch.
- C. Provide necessary backboxes for the installation of Division 28 equipment. Coordinate backbox requirements with the Division 28 Contractor prior to installation.
- D. The raceway systems, wire and cable required to support the low voltage systems shall be installed in accordance with the following general installation requirements:
 - 1. Provide a nylon pull-line in each unused conduit. The pull-line shall have a tensile strength of 200 pounds for conduit sizes up to 1 inch, 400 pounds for conduit sizes up to 2 inch and 600 pounds for larger sizes.
 - 2. Conduits shall be clearly identified at both ends as to their destination. Where more than one conduit serves the same location, each conduit should be identified with a unique number.
 - 3. Open ends of conduits shall be plugged to prevent the entrance of moisture or foreign material. If moisture or foreign material is found at the time the cables are being installed, promptly and thoroughly clean the conduit before installation of cables.
 - 4. Conduits shall be securely fastened in place and free from burrs, defects, or obstructions that could interfere with installation of cables.
 - 5. Conduit that terminates at a connection backboard (unless otherwise specified on the drawings) shall terminate at the designated backboard either 12 inches above the floor or 12 inches below the ceiling or at the wireway indicated.
 - 6. Conduit shall be reamed. Where the conduit enters pull boxes, cabinets, wireways, or outlets, the conduit shall be secured by locknut(s) and provided with an insulated bushing on the conduit end.

7. Unused conduits shall be marked as noted above and provided with metal blank end discs and a bushing.
- E. Installation of these conduit, raceway, wiring and grounding systems requires extensive interfacing. Coordinate during the planning and installation of this work to assure that the resulting installation is acceptable to the other subcontractors, the General Contractor, and the Owner.
- F. Assure that backboxes in concrete and block walls are installed properly. This includes the proper depth relationship between the lip of the backbox and the finished surface of the wall, verification that the plane of the front of the backbox is parallel with the plane of the finished wall and confirmation that the sides of the backbox are vertical.
- G. Conduits 2" and smaller installed for Fire Alarm systems shall be equal to Allied True Color Fire Alarm EMT, red in color. Junction boxes for Fire Alarm systems shall be factory painted red.

3.3 RACEWAY INSTALLATION - SPECIAL ABOVE-GROUND REQUIREMENTS

- A. Conduits shall be concealed in the building construction except in electrical rooms, mechanical rooms and where exposed runs are indicated. Exposed conduits shall be run parallel to walls and ceilings and at the ceiling wherever possible.
- B. Conduits, whether exposed or concealed, shall be securely supported and fastened at intervals of nominally every 10 feet and within 36 inches of each outlet, ell, fitting, panel, etc. Suspended conduits shall be supported by metal rings or by trapeze hangers of Unistrut or Kindorf channel and threaded steel rods. Multiple runs of conduit on ceilings and walls shall be mounted on Unistrut or Kindorf channel. Perforated plumber's tape shall not be used. Single runs of exposed conduit shall be supported with steel pipe straps. Conduit shall not be supported from ducts, plumbing or other piping or from other conduits but only from building structural elements. Reference additional conduit support requirements under provisions of Section 262727.
- C. Provide suitable fittings to accommodate expansion and deflection where conduit crosses seismic, control and expansion joints, or wherever conduit may be affected by dissimilar movements of the supporting structure.
- D. Where conduit is exposed to the weather or in wet locations, make joints liquid and gastight. Ends of such conduits shall be sealed after conductors.
- E. Keep conduit at least 6 inches from hot water or steam pipes and at least 18 inches from the covering on flues and the like.
- F. Do not cut, notch or drill structural framing members for the installation of conduit without the Owner's advance approval in each case.
- G. Rigid steel conduit shall be used at roof penetrations. Where conduits pass through the roof, provide channel supports below the roof spanning the structural elements of the roof and braced to the building structure in at least two (2) directions at right angles to one another.

The conduit penetrating the roof shall be secured to the supports at two (2) points below the roof as required to render the portion above the roof rigid.

- H. Where flexible metal conduit is used for equipment connections or other special (approved) situations provide a continuous copper ground conductor sized in accordance with the applicable codes. Liquidtight flexible metal conduit shall be used for equipment connections in damp and wet areas. Flexible conduit used for connections to vibrating equipment shall be approximately 3 feet (9.8 m) long and contain one (1) 90 degree (1.57 rad) bend.
- I. Install conduits so that there is a minimum of 12 inches of clearance between bottom of conduit and top of removable ceiling tiles.
- J. Where one hole straps are used for horizontal conduit runs, locate screw on the bottom side of the conduit.

3.4 SLEEVES

- A. Provide sleeves of sufficient size to permit ready installation of each conduit which passes through concrete walls or suspended slabs. Sleeves in concrete beams, joists, columns or footing walls may be installed only where permitted by the Owner.
- B. For conduit that passes through suspended concrete slabs, place sleeves with the top one inch above finished slab and the bottom flush with underside of slab. In other cases, place sleeves with the ends flush with the concrete surfaces. Space sleeves at least three diameters apart on center and more if required by the Owner.
- C. Where conduits pass through fire resistive walls, ceilings or floors, sleeves shall be packed with fire resistive compound equal to 3M Fire Barrier.
- D. Penetrations through fire rated floors, ceilings and walls shall be sealed using an approved fire barrier sealant. Fire barrier sealants shall be a UL Rated material classified for use in through-penetration fire stop systems, and shall have ICBO, BOCAI, and SBCCI (NRB 243) approved rating per ASTM-814 (UL 1479). The sealant shall be equal to 3M CP-25 caulk, FS 195 strips and CS 195 sheet forms or an approved equal. Acceptable manufacturers are STI, 3M, Pensil, Hilti, Dow, Fyre Putty, Hevi-Duty and Nelson.
 - 1. Where sleeves penetrate existing fire resistive concrete walls or floors, the annular space around the sleeve shall be filled with fire resistive intumescent compound equal to STI "Spec Seal" firestop sealant as manufactured by Specified Technologies, Inc., Somerville, New Jersey. If the annular space exceeds $\frac{3}{4}$ inch, it shall be filled instead with fire resistive grout equal to STI "Spec Seal" firestop mortar.
 - 2. Where sleeves penetrate fire resistive sheetrock walls or ceilings or where they penetrate fire resistive suspended ceilings, the annular space around the sleeve shall be filled with fire resistive intumescent compound equal to STI "Spec Seal" firestop sealant.
 - 3. Where sleeves pass through fire resistive walls, ceilings or floors, sleeves shall be packed with fire resistive intumescent compound equal to STI "Spec Seal" firestop putty.
 - 4. A manufacturer's supplied installation detail shall be submitted for each type of assembly with the UL approval and limitations indicated.

3.5 FLASHING OF ROOF CONDUIT PENETRATIONS

- A. Conduit penetrations shall be coordinated with the roof installer. Flashings and sealants shall be installed by the roof installer.

END OF SECTION 26 0530

SECTION 26 0531 - SURFACE RACEWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Multi-outlet assemblies (Surface Metal Raceway)
- B. Wireways

1.2 RELATED SECTIONS

- A. Section 260526 - Grounding and Bonding
- B. Section 262726 - Wiring Devices: Receptacles
- C. Section 262727 - Supporting Devices

1.3 REFERENCES

- A. National Electrical Code Article 362 - Wireways, Article 374 - Auxiliary Gutters
- B. National Electrical Contractor's Association (NECA) Standard of Installation
- C. NEMA WD 6 - Wiring Device Configurations
- D. Underwriters Laboratories (UL) Standard of Safety 870 - Wireways, Auxiliary gutters and Associated Fittings

1.4 SUBMITTALS

- A. Product Data: Provide dimensions, knockout sizes and locations, materials, fabrication details, finishes, and accessories.

1.5 REGULATORY REQUIREMENTS

- A. Furnish products listed and classified by Underwriters Laboratories, Inc. or other testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 WIREWAY (GUTTER)

- A. Manufacturers: Square D Company Model LD SQUARE-Duct NEMA 1, or approved equal
- B. Description: General purpose, 16 gauge steel minimum, with full length removable screw cover and end caps with full gasketing as required.
- C. Knockouts: Manufacturer's standard.
- D. Size: Cross-sectional dimensions shall be eight (8) times diameter of largest conduit entering from side, with a minimum dimension of 4×4 inches, unless otherwise indicated. Length shall be as required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install Products in accordance with manufacturer's instructions.
- B. Use flat-head screws, clips, and straps to fasten raceway channel to surfaces. Mount plumb and level.
- C. Wireway Supports: Provide steel channel as specified in Section 262727.
- D. Close ends of wireway and unused conduit openings.
- E. Ground and bond raceway and wireway under provisions of Section 260526.

END OF SECTION 26 0531

SECTION 26 0532 - BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Wall and ceiling outlet boxes
- B. Floor boxes
- C. Pull and junction boxes
- D. Access doors

1.2 RELATED SECTIONS

- A. Section 260530 - Conduit
- B. Section 262716 - Cabinets and Enclosures
- C. Section 262726 - Wiring Devices

1.3 REFERENCES

- A. NECA - Standard of Installation
- B. NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies
- C. NEMA OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports
- D. NEMA OS 2 - Non-metallic Outlet Boxes, Device Boxes, Covers and Box Supports
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- F. NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Product Data: Provide data for wall and ceiling outlet boxes, pull, and unction boxes.
- B. Record actual locations and mounting heights of outlet, pull, and junction boxes on project record documents.

1.5 REGULATORY REQUIREMENTS

- A. Provide products listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 OUTLET BOXES

- A. Manufacturers: Appleton, Crouse Hinds, Killark, O Z Gedney, Raco/Bell, Steel City, or equal.
- B. Boxes shall accommodate the devices to be installed and shall be sized as required by the applicable codes for number and size of conduits and conductors entering and leaving. Round or octagon boxes will not be permitted unless specifically called for. Boxes shall have galvanized finish.
- C. Boxes shall be of code gauge steel and provided with plaster, tile or other appropriate device rings.
- D. Outlet boxes and device boxes mounted in non-masonry walls shall be minimum 4 inches square by 2-1/8 inches deep exclusive of rings and shall be provided with covers or device rings as specified.
- E. Outlet boxes and device boxes mounted in masonry walls shall be single gang or double gang masonry boxes with a minimum depth of 2½ inches for 4 inch masonry walls and 3½ inches for 6 inch or 8 inch masonry walls (exclusive of rings).
- F. Multi-gang boxes shall be one-piece. Do not use built-up boxes.
- G. Weatherproof boxes shall be non-rusting cast metal with threaded hubs. Boxes shall have screw mounted, gasketed covers. Plugs shall be installed in all unused holes.

2.2 ACCESS DOORS

- A. Minimum size of access doors shall be 12×12 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify exact locations of floor boxes and outlets prior to rough-in.

3.2 GENERAL INSTALLATION

- A. Install boxes in accordance with NECA "Standard of Installation."

- B. Install in locations as shown on drawings, and as required for splices, taps, wire pulling, equipment connections and in compliance with regulatory requirements.
- C. Electrical boxes are shown on drawings in approximate locations unless dimensioned. Adjust box location up to 10 feet if required to accommodate intended purpose.
- D. Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- E. Boxes shall be supported independently of the conduit system. Do not fasten boxes to ceiling support wires.
- F. Where boxes occur in pre-cast concrete construction, coordinate installation with the Contractor building the precast construction to produce shop drawings showing box locations. Provisions shall be made for conduit entry from top or bottom of wall panels. Conduit and boxes shall be installed concealed and flush respectively. These requirements shall be met whether the precast work is done at the site or a location remote from the site.
- G. Boxes shall be plumb. Supports shall be noncombustible and corrosion resistant. In suspended ceilings, bar hangers shall be used to support the boxes from the ceiling channels. Refer to mechanical drawings for exact heights of outlets not specified herein or indicated on the drawings. Unused knockouts in boxes shall be left sealed.
- H. Do not mount control or disconnecting devices more than 6 feet 6 inches above finish floor.
- I. Do not locate cabinets, outlets or other apertures larger than 16 square inches in rated fire walls.
- J. Prior to installation, the Owner reserves the right to relocate outlets or devices within 6 feet of the location indicated on the plans at no additional cost.
- K. Where rigid conduit enters a box, fitting or device through a knockout, double locknuts and an insulated metallic bushing shall be used. EMT shall terminate at knockouts with an insulated throat fitting and one locknut. Connectors shall be made up tight to ensure electrical continuity of the raceway system.
- L. Provide necessary supports and backing for enclosures and equipment.
- M. Attach boxes, outlets, straps, cabinets and equipment to wood with wood or lag screws, to metal with machine screws or bolts, and to concrete with expansion anchors or self-drilling metal anchors and machine screws or bolts. Use size and number of attachments to support equipment weight with a safety factor of four (4) minimum.
- N. Provide access doors where boxes are not exposed or located within an accessible ceiling unless indicated to be provided under other divisions.
- O. Junction boxes exposed in unfinished areas or concealed in ceilings shall be painted to identify system as follows:
 - 1. Red: Fire Alarm

2. Silver: Power
3. Orange: NEC 700 Emergency
4. Yellow: NEC 702 Standby

3.3 OUTLET BOX INSTALLATION

- A. Each lighting outlet, switch, receptacle and other miscellaneous device shall be provided with a suitable box.
- B. Align adjacent wall mounted outlet boxes for receptacles, data/telephone outlets, and similar devices.
- C. Use flush mounting outlet box in finished areas.
- D. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.
- E. Outlet boxes installed in masonry walls shall be centered in a course of masonry. Masonry boxes shall be mounted as follows:
 1. From floor to height of 6 feet, mount so that bottom of box rests on block joint.
 2. Above 6 feet, mount so that top of box rests on block joint.
- F. Do not install flush mounting box back-to-back in walls; provide minimum of 6 inches separation. Provide minimum of 24 inches separation in fire-rated assemblies.
- G. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
- H. Use stamped steel bridges to fasten flush mounting outlet box between studs.
- I. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- J. Use adjustable steel channel fasteners for hung ceiling outlet box.
- K. Use cast outlet box in exterior locations, where exposed to the weather and wet locations.
- L. Where two or more of the same type devices occur adjacent to each other, they shall be in a gang type box with a gang type cover. Where different type devices occur adjacent to each other, space outlet boxes so that finish plates will be spaced 1 inch apart. Where receptacles or switches are shown side by side but at different heights, they shall be centered one above the other unless noted otherwise.
- M. Unless otherwise indicated, switch boxes shall be mounted with top of box at 48 inches, over counter convenience outlet boxes shall be centered 8 inches above the counter top or higher as required to clear the backsplash and other convenience outlets shall be mounted with center at 18 inches above the finished floor. Coordinate outlet locations and provide box extensions or other equipment as required where outlets occur in cabinet backs.

- N. Outlets in acoustical ceilings are to be in the center of the acoustical tile or in the center of a joint in the acoustical tile.
- O. Align outlets horizontally or vertically for a uniform and neat appearance.

3.4 PULL AND JUNCTION BOX INSTALLATION

- A. Pull boxes and junction boxes shall be provided as indicated on the drawings and/or as required.
- B. Boxes larger than 200 cubic inches or 18 inches in any dimension shall use a hinged enclosure in interior dry locations, surface-mounted cast metal box in other locations.
- C. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
- D. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel.
- E. Mount pull and junction boxes a minimum of 4' from steam piping.

3.5 ADJUSTING

- A. Adjust floor box to be flush with finish flooring material.
- B. Adjust flush-mounting outlets to make front flush with finished wall material.
- C. Install knockout closures in unused box openings.

END OF SECTION 26 0532

SECTION 26 0548 - VIBRATION ISOLATION FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 SCOPE

- A. Provide and adjust vibration isolation components and materials required to isolate the building structure and occupied spaces from vibrating equipment as specified by this section

1.2 RELATED DOCUMENTS

- A. General Provisions of the Contract and applicable requirements of Division 01 and this section apply to the work specified in this section.
- B. Division 09 for wall construction
- C. Section 230548 - Vibration Isolation
- D. Division 23 – Heating Ventilating, and Air-Conditioning (HVAC)

1.3 SUBMITTALS

- A. Submit complete product data to the architect in accordance with the General Provisions of the Specifications before materials are delivered to the job site.
- B. Submit to the Acoustical Consultant shop drawings showing the following information so that isolation system can be checked for compliance with the specifications:
 - 1. Sizes, placement and type of isolators, seismic snubbers, and total base mass (weight) if it is a concrete inertia base.
 - 2. Weight distribution on isolators.
 - 3. Isolator schedule to show size, type, load, and static deflection of each isolator.
 - 4. Number and color-code of each isolator to show its location.
 - 5. Isolator adjustment procedures for setting and adjusting the isolation devices so that the isolator mount selections can be checked for compliance with the specification.
- C. When manufacturers provide equipment bases, submit calculations verifying factory base stiffness is equal or equivalent to stiffness of base specified in the Vibration Isolation Schedule.

1.4 ACCEPTABLE MANUFACTURERS

- A. Amber Booth
- B. Mason Industries, Inc.

- C. Kinetics Corporation
- D. Approved equal, meeting the conditions and requirements specified herein

1.5 CONTRACTOR RESPONSIBILITY

- A. Vibration isolation devices, including auxiliary steel bases and pouring forms, shall be designed and furnished by a single manufacturer or supplier.
- B. Furnish a balanced set of vibration isolators for each piece of equipment listed in the Vibration Isolation Schedule.
- C. Procure from the vibration isolation manufacturer instructions and procedures on how to install and adjust vibration isolators.
- D. Adequately restrain equipment to resist seismic forces. Design and select restraint devices to meet seismic requirements as defined in the latest issue of the Uniform Building Code and applicable state and local codes in accordance with project area Seismic Zone with a minimum restraint capability of 1.0 g.
- E. Coordinate with the structural engineer to ensure mounting attachment points for seismic restrained springs and seismic snubbers will withstand forces generated from the maximum acceleration rating of the restrained springs and snubbers.
- F. Select, install, adjust, and verify the performance of vibration isolators that will meet the requirements given on the plans or in the specifications.
- G. Provide assistance necessary to ensure correct installation and adjustment of the isolators.
- H. Changes or additions necessary to meet the requirements given on the plans or in the specifications are to be made without expense to the owner.

1.6 QUALITY ASSURANCE

- A. Isolators shall operate in the linear portion of their load-versus-deflection curve.
- B. The ratio of lateral to vertical isolator stiffness to be not less than 0.9 nor greater than 1.5.
- C. Bring to the attention of the Acoustical Engineer discrepancies between this section and other related documents

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Where exposed to the atmosphere, steel to be finished with dry powder coating for corrosion protection; hardware (bolts and capscrews) to be Zinc electroplated; springs to be dry powder coated.

2.2 ISOLATORS

- A. Type N-2: Neoprene Seismic Mount

- 1. Captive neoprene mounting shall consist of a steel housing with a captive steel insert embedded in neoprene to prevent contact between the housing and the central threaded insert.
- 2. Isolator shall contain a cast-in tapped steel load plate to permit bolting to the supported equipment.
- 3. Snubbing to limit deflection in upward, downward, and horizontal directions. Capacity to withstand not less than 1.0 g without noticeable deformation.
- 4. Isolators shall be selected to provide the minimum operating static deflection tabulated in the Vibration Isolation Schedule, while not exceeding the published load capacity for the isolator used.
- 5. Isolator shall have a minimum deflection of 0.15 inch.
- 6. Isolators shall be color-coded to identify the load capacity.
- 7. Acceptable Products:

- a. Model RCA, RBA by Mason
- b. Model RQ by Kinetics

- B. Type N-5: Neoprene Pad

- 1. Isolator shall consist of 3/4-inch thick molded neoprene.
- 2. Pad to either be a ribbed or waffle type construction.
- 3. Isolator shall have a 50-durometer rating.
- 4. Isolator shall be loaded to limit surface pressure to a maximum of 50 psi.
- 5. Isolator to be equipped with a steel plate bonded to the neoprene pad if required for proper load distribution.
- 6. Acceptable Products:

- a. Model Super W by Mason

- C. Type H-1: Spring Hanger

- 1. Hanger to consist of a combination of a steel spring and a fiberglass or neoprene isolator placed in series and encased in a welded steel bracket.
- 2. Isolator to have minimum operating static deflection as tabulated in the Vibration Isolation Schedule.
- 3. Isolator shall be designed to carry five (5) times overload without failure.

4. Spring shall have minimum additional travel to solid equal to 50% of rated deflection.
5. Isolator to be installed to allow up to fifteen (15) degrees of rod misalignment without metal-to-metal contact or other isolation short circuit.
6. Acceptable Products:
 - a. Model 30N by Mason
 - b. Model SRH by Kinetics
 - c. Model BSRA by Amber Booth

2.3 SEISMIC SNUBBERS

A. General:

1. Provide restraints capable of safely accepting external forces as defined in latest issue of International Building Code and applicable state and local codes without failure, to maintain equipment, piping, duct, and variable volume boxes and fan coil units in a captive position.
2. Seismic devices should not interfere with vibration isolation during normal operation. Conflicts between vibration isolation and seismic restraints shall be brought to the attention of the Acoustical Consultant.
3. Seismic mounts shall have an anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings.
4. Submit calculations by registered structural engineer to verify snubber capacities.

B. Type E-3: Seismic Restraint Metal Cable:

1. Stainless steel aircraft cables and steel U-bolt clips.
2. Cables to attach to equipment frame and to structure with steel angle clips.
3. Cables shall be installed with enough slack to allow proper functioning of vibration isolators during normal operation and to become tight and restrict excessive motion from seismic input.
4. Cables to have a maximum spacing of 20 feet on center for ductwork and piping.
5. Acceptable Products:
 - a. Model SCB/SCBH by Mason.
 - b. Model Cab/Rig by ISAT.

2.4 MISCELLANEOUS SUPPORT

A. Type WB-1: Neoprene washers and bushings

1. Washer-bushing shall be manufactured of bridge bearing neoprene.
2. Washer-bushing maximum loading not to exceed 1000 psi.
3. Washer-bushing to be used such that direct contact between bolt and equipment is eliminated.
4. Acceptable Products:
 - a. Model HG by Mason

- B. Type CS-1: Cushion Sleeve
 - 1. Fiberglass sleeve sized to fit pipe.
 - 2. Acceptable Products:
 - a. Owens Corning Fiberglass 25 ASJ/SSL Service Jacket, or approved equal.
 - b. Johns Manville Micro-Lok Fiberglass Pipe Insulation, or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. Isolate Electrical equipment from the building structure by means of vibration isolators as stated herein.
- B. Install isolation systems (isolators, bases, and related hardware) in accordance with the manufacturer's written Installation Instructions.
- C. Verify that there are no rigid connections between equipment and building structure that degrade the vibration isolation systems specified herein.
- D. Do not use wall, floor, or ceiling penetrations to support conduit, wiring, or cable trays. Support conduit, wiring, or cable trays just prior to and just after the penetration, so that the penetrating element is centered in penetration.
- E. Bring to the Acoustical Engineer's attention prior to installation conflicts with other trades which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation will be at the responsible contractor's expense.
- F. Size anchoring bolts to isolators or snubbers withstand seismic lateral shear and tensile failure and isolate bolts from direct contact with the structure using Type WB-1 isolator.

3.2 ISOLATION OF EQUIPMENT AND PANELS AT PARTITIONS ADJACENT TO OCCUPIED SPACES

- A. In electrical, mechanical, and elevator equipment rooms, isolate electrical equipment, panels, and devices mounted to partitions (partitions are defined as walls, floors, and ceilings) adjacent to classrooms, offices, conference rooms, or other occupied spaces as follows:
 - 1. Isolate the supports for equipment mounted to the floor with N-5/WB-1 isolators.
 - 2. Isolate the supports for equipment mounted to the wall with N-2 isolators.

3.3 ELECTRICAL EQUIPMENT ISOLATION

- A. Conduit Isolation on Occupied Walls

1. Do not use conduit clamps or hangers at the flex conduit. The first point of contact with walls should be past the flex conduit.
2. Flex conduit shall be no shorter than 3 feet in length.
3. Individual conduit
 - a. Isolate from structure using type CS-1 sleeve.
4. Conduit grouped on unistrut
 - a. Isolate unistrut from structure using Type N-2 neoprene seismic mount.
 - b. Alternatively, the unistrut can be rigidly attached to structure if conduits are isolated from the unistrut with type CS-1 sleeve.

B. Transformer Isolation

1. Isolate transformers from direct contact with the building structure as follows:
 - a. Isolate floor-mounted transformers using isolator Type N-5/WB-1 isolators.
 - b. Isolate hung transformers using isolator Type H-1 (1.0" deflection) and E-3 seismic restraints.
 - c. Isolate wall-mounted transformers using isolator Type N-2 neoprene seismic mount.
2. Do not allow the transformer to be in direct contact with walls. Allow at least 6 inches of clearance between floor mounted transformer and walls.
3. Cable duct between the transformer and the first panel is not allowed.

3.4 CONDUIT ISOLATION

- A. Not applicable.

3.5 PENETRATION ISOLATION

- A. See also, Division 09 for wall construction.

B. Scope

1. Penetration requirements identified in this section will be applied to acoustical walls, floors, and ceilings.

C. Method:

1. Isolate conduit over 2 inches in diameter at penetrations as follows:
 - a. Provide a sheet metal (22 gauge) sleeve to cover the perimeter of a 1 inch to 1-1/2 inch (1/2 inch to 3/4 inch on each side) oversized penetration cut.
 - b. Plaster or caulk sleeve to the wall, ceiling, or floor, to ensure an airtight seal.

- c. If ductwork or pipework penetrates a double wall, use a separate sleeve at each side of the wall (allow no sleeve connection between walls).
 - d. Pack the gap between the penetrating duct or pipe and the sleeve with Acoustical Insulation and seal airtight on both sides of the wall, floor, or ceiling with an outer layer of Acoustical Sealant.
 - e. Do not use wall, floor, or ceiling penetrations to support pipework or ductwork. Support pipe or duct just prior to and just after the penetration, so that the pipe or duct is centered in penetration
 - f. Use the above penetration treatment regardless of the existence of external duct or pipe insulation. Size penetration large enough to pack additional Acoustical Insulation and apply Acoustical Sealant between the external insulation and the sheet metal sleeve.
2. Isolate conduit 2 inches or less in diameter at penetrations as follows:
- a. Oversize penetration cut by 1/4 inch (1/8 inch each side).
 - b. Seal airtight on both sides of the wall, floor, or ceiling with Acoustical Sealant.
 - c. Do not use wall, floor, or ceiling penetrations to support pipework. Support pipe just prior to and just after the penetration, so that pipe is centered in penetration.
 - d. Use the above penetration treatment regardless of the existence of external pipe insulation. Size penetration large enough to apply Acoustical Sealant between the external insulation and the pipes.

3.6 MISCELLANEOUS

- A. Coordinate with other trades and structural engineer to ensure mounting attachment points for seismic restrained springs and seismic snubbers called out in this specification will withstand forces generated from the maximum acceleration rating of the restrained springs and snubbers.

END OF SECTION 26 0548

SECTION 26 0549 - SEISMIC CONTROLS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. The work in this section consists of providing engineering and materials necessary for seismic restraints for the electrical systems and equipment provided in this project in Division 26 through 28.

1.2 RELATED SECTOINS

- A. Division 26 – Sections where conduit and equipment are furnished.
- B. Division 28 – Sections where conduit and equipment are furnished.

1.3 WORK INCLUDED

- A. This section provides minimum acceptance requirements for seismic restraints for conduit and equipment.
- B. Engineering and seismic controls provided in Section 230548 shall be provided by one source for single source responsibility and coordination.

1.4 QUALITY ASSURANCE

- A. Unless otherwise directed by the local authority having jurisdiction, the following codes and standards apply:
 - 1. International Building Code 2018
 - 2. American Society of Civil Engineers Standard ASCE 7-16
- B. Manufacturer's Qualifications: Vibration Isolation and Seismic Control Manufacturers Association (VISCMA) "Regular Member" firms as defined by VISCMA, <http://www.viscma.com/>
- C. Restraint products tested for performance by third parties.
- D. The manufacturer provided services in this section shall review all equipment submittals prior to preparation of project specific submittal for this project. The manufacturer shall review equipment bases provided with equipment and if bases are not compliant with this section, provide supplemental bases.
- E. The following guides may be used for supplemental information on typical seismic installation practices provided that all work conforms to the International Building Code and ASCE.

Where a conflict exists between the guides and these construction documents, the construction documents will preside.

1.5 SEISMIC CRITERIA

- A. This section documents the Seismic criteria that apply to this project.
 - 1. Seismic Supports are required for Division 26 and 28.
- B. Design and select restraint devices to meet seismic requirements as defined in the International Building Code, and applicable state and local codes and the following project specific requirements.
 - 1. North Academic Center:
 - a. Seismic Design Category: C
 - b. Risk Category: III
 - c. Electrical system importance factor: All Div 26 and 28 piping, systems and equipment , $I_p = 1.0$
 - 2. GeoEco Plant (GEP):
 - a. Seismic Design Category: C
 - b. Risk Category: IV
 - c. Electrical system importance factor: All Div 26 and 28 piping, systems and equipment , $I_p = 1.5$
 - d.
- C. Engineered supports are required for electrical systems furnished in this project for all importance factors.

1.6 SUBMITTALS

- A. Pre-Installation-Part 1
 - 1. Submit the following for review and acceptance to the Owner's representative.
 - a. Supports
 - 1) Provide submittal drawings for all devices specified herein in Division 26 and 28 and as indicated and scheduled on the drawings. Submittals shall indicate full compliance with the device specification in Part 2. Any deviation shall be specifically noted and subject to engineer approval. Submittals shall include device dimensions, placement, attachment and anchorage requirements.
 - 2) Provide calculations for selection of seismic/wind restraints and their positive attachments, certified by a qualified professional engineer, licensed in the state/province of the project.

- 3) Seismic forces at attachment and attachment methods shall be clearly indicated for review by the project structural engineer.
 - 4) Stamped submittal package shall be project and product specific. Generic stamped calculations are not acceptable.
 2. For fuel fired, active, or energized equipment with an $I_p=1.5$ in Seismic Design Categories C through F:
 - a. Provide submittal of the manufacturer's certification that the equipment is seismically qualified by one of the following methods.
 - 1) Analysis (only allowed for nonactive components)
 - 2) Testing in accordance with alternatives identified in ASCE 13.2.5.
 - 3) Experience data in accordance with alternative identified in ASCE 13.2.6.
 - b. Active equipment, as defined in ASCE, constitutes equipment with moving parts that rotate, move mechanically or are energized in operation.
- B. Pre-Installation-Part 2
 1. After acceptance from the registered design professional, submit design and documentation for Approval by the Authority having jurisdiction in accordance with ASCE 7-16 part 13.2.1.
- C. Post Installation
 1. Submit seismic restraint product manufacturer inspection certificate in accordance with Part 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS (REFER TO SECTION 230549)

- A. Vibro-Acoustics
- B. Amber Booth
- C. Kinetics
- D. Korfund
- E. Mason Industries

2.2 SEISMIC/WIND RESTRAINTS

- A. Seismic Cable Restraints: Vibro-Acoustics Type BulletBrace™ – Preassembled, adjustable seismic sway bracing restraints shall consist of 7x19 galvanized steel aircraft cable sized to resist seismic loads. Cable restraint system shall be completely preassembled to eliminate

onsite assembly of restraint components, and shall allow quick and easy adjustment on the length of the cable after the installation to remove excessive sag on the cable. Cable end connections shall use heavy duty steel brackets, thimbles with Bulletlock cable installation mechanism. Type SRK – wire rope restraints shall have wire rope clips. All seismic cable restraint assembly capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.

- B. Rigid Restraints: Vibro-Acoustics Type RRK-V – Seismic rigid sway bracing restraints shall include heavy duty brackets made of high-strength, low alloy steel designed to provide strength to withstand seismic load. To prevent site confusion, brackets shall be of a universal design for both structural and equipment/conduit attachments. The brackets shall accommodate post-installation of seismic restraints without the requirement of disassembling the hanger rod or any other support component. Rigid restraint brackets shall be color-coded for capacity identification. Rigid restraint capacities shall be determined through third party testing per ANSI/ASHRAE Standard 171, and test reports will be available by the manufacturer upon request.
- C. Seismically Rated Beam Clamp: Vibro-Acoustics Type BulletClamp™ BC-50 – Seismically rated beam clamps for attachment of seismic cable restraints and rigid restraints to structural steel without drilling the structure. Beam clamp shall be constructed of a ductile cast frame, case hardened cone point set screw and related hardware. Clamp frame shall be zinc plated with supplemental yellow chromate treatment, and hardware and set screw shall be zinc plated for corrosion protection. Clamp design shall allow installation of the restraint bracket to the clamp and the clamp to structure with a single attachment point. Published seismic beam clamp capacities at specified angles shall be established through testing. Test reports will be available by the manufacturer upon request.
- D. Hanger Rod Stiffener Clamp: Vibro-Acoustics Type VAC – Structural steel angle attached with a formed steel clamp to threaded rod support. Steel angle to be provided by contractor; VAC clamp to be provided by seismic restraint manufacturer.
- E. Seismic Restraint Brackets: Vibro-Acoustics Type SRB – Formed steel brackets for securing floor-mounted equipment complete with pre-drilled holes. Brackets shall be galvanized or powder coated enamel for corrosion protection. Brackets shall be furnished with grommet washers for vibration isolated equipment.
- F. Seismic Snubber: Structural steel angle(s) with surfaces covered with ribbed neoprene pads to cushion contact with snubber. Customized snubber designs may use other structural shapes and configurations as required. Snubbers shall be designed to limit excessive vibration isolated equipment motion due to wind or seismic loads to no more than 1/4" (6 mm) in any direction.
- G. Concrete Anchor Bolts: Post-installed anchors in concrete shall be qualified for seismic/wind restraint application.
 - 1. Mechanical anchor bolts: Concrete screw type, drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. (In accordance with ACI 355.2 and ICC-ES AC193)

2. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. (In accordance with ACI 355.4 and ICC-ES AC308)

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide in accordance with manufacturer's instructions.
- B. Coordinate locations and sizes of structural supports with locations of vibration isolators and seismic/wind restraints (e.g., roof curbs, equipment skids, etc.).

3.2 CLEARANCES

- A. Maintain a minimum of 3" in all directions between any sprinkler drop or sprig and the following items: permanently attached equipment including their structural supports and bracing; and other distribution systems including their structural supports and bracing.
 1. Exception: sprinklers using flexible sprinkler hose.

3.3 SEISMIC/WIND RESTRAINTS

- A. General:
 1. Conduit and equipment shall be restrained to resist seismic/wind forces per the applicable building code(s) as a minimum. Restraint attachments shall be made by bolts, welds or any other positive fastening methods. Friction shall not be considered as positive attachment. All attachments shall be proven capable of accepting the required wind and seismic loads by calculations. Additional requirements specified herein are included specifically for this project.
 2. Install seismic and wind restraint devices per the manufacturer's submittals. Deviation from the manufacturer's instructions shall be reviewed and approved by the manufacturer.
 3. Attachment to structure for suspended conduit and equipment: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords or bar joists, or at concrete members.
 4. Wall penetrations may be used as bracing locations provided the wall can provide adequate resistance without significant damage.
 5. Provide hanger rod stiffeners where indicated or as required to prevent buckling of rods due to reaction caused by seismic forces.
 6. Where rigid restraints are used on conduit or equipment, support rods for the conduit or equipment, must be supported by anchors rated for seismic use. Post-installed concrete anchors must be in accordance with ACI 355.2.

7. Attachments for component anchorage shall meet the requirements of ASCE 13.4.
- B. Concrete Anchor Bolts:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre- or post-tensioned tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Install neoprene grommet washers on equipment anchor bolts where clearance between anchor and equipment support hole exceeds 1/8" (3.2 mm).
 4. Mechanical Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 5. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 6. Set anchors to manufacturer's recommended torque, using a torque wrench.
- C. Equipment Restraints:
1. Seismically restrain equipment as indicated on the schedule. Install fasteners, straps and brackets as required to secure the equipment.
- D. Conduit Systems:
1. Exemptions: Follow exemptions on applicable building codes as specified in section 1.6.
 2. Restraint spacing:
 - a. Space lateral supports a maximum of 40' (12 m) o.c. and longitudinal supports a maximum of 80' (24 m) o.c.
 - b. For conduit risers, restrain the conduit at floor penetrations using the same spacing requirements as above.
 3. Brace a change of direction longer than 12' (3.7 m).
 4. Longitudinal restraints for single conduit support shall be attached directly to the conduit, not to the conduit hanger.
 5. For supports with multiple conduits (trapezes), secure conduits to trapeze member with clamps approved for application.
 6. Install restraint cables so they do not bend across edges of adjacent equipment or building structure.
 7. Install flexible conduit connectors where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

3.4 INSPECTION AND CERTIFICATION

- A. After installation, arrange and pay for the seismic restraint product manufacturer, or representative, to visit the site to verify that the seismic and wind restraint systems are installed properly, and shall submit a certificate so stating.

3.5 VIBRATION ISOLATION

- A. Refer to Sections 230548 for systems and equipment requiring vibration isolation. Seismic restraints shall factor vibration of spring isolation equipment.

END OF SECTION 26 0549

SECTION 26 0553 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Nameplates
- B. Wire and Cable Markers
- C. Pull and Junction Box Identification
- D. Device Plate Identification

1.2 RELATED SECTIONS

- A. Section 262726 - Wiring Devices

PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Nameplates shall be laminated phenolic with lettering engraved through the outer covering. Lettering shall be ½ inch high. Nameplates shall be securely fastened to the equipment with No. 4 Phillips, round-head, cadmium-plated, steel self-tapping screws or nickel-plated brass bolts. Nameplate colors shall be as follows:
 - 1. Normal Power – Black w/ white letters
 - 2. Emergency Power – Red w/ white letters.

2.2 LABELS

- A. Labels shall be Nylon stick-on labels equal to 3M. Label shall be white with black lettering for concealed locations and clear with black lettering for exposed locations.

2.3 WIRE AND CABLE MARKERS

- A. Manufacturers: W. H. Brady Co, Seton, Tyton.
- B. Markers shall be split sleeve or tubing type.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive identification materials.

3.2 NAMEPLATE INSTALLATION

- A. The following items shall be equipped with nameplates:
 - 1. Motor starters, motor control switches, pushbutton stations, control panels and time switches.
 - 2. Disconnect switches, panelboards, switchboards, and separate overcurrent devices mounted in switchboards. Indicate voltage and phase.
 - 3. Circuit breakers, contactors and relays in separate enclosures.
 - 4. Switches or dimmers controlling luminaires not located within sight of the controlling device.
 - 5. Special electrical system components, terminal cabinets, equipment cabinets and equipment racks.
 - 6. Wall switches controlling equipment.
 - 7. Special receptacles.
 - 8. See Section 262726 for required identification of general wiring device plates.

3.3 LABEL INSTALLATION

- A. The following items shall be equipped with nylon stick-on labels:
 - 1. Provide labels for:
 - a. Receptacles
 - b. Lighting switches
 - c. Motor toggle switches
 - d. Special receptacles
- B. Locate label on cover plate. Label shall indicate branch circuit panel and circuit number information.
- C. Labels shall be Nylon stick-on labels equal to 3M. Label shall be white with black lettering for concealed locations and clear with black lettering for exposed locations.

3.4 WIRE IDENTIFICATION

- A. Provide wire markers on each feeder conductor in panelboards, distribution panelboards, gutters, pull boxes and switchboards.
- B. Identify with origin and destination. Wire marker color shall match the phase color.

3.5 PULL BOX AND JUNCTION BOX IDENTIFICATION

- A. Each pull and junction box shall be neatly identified with permanent black marker or stick on labels on the outside of the box (where the box is concealed) and on the inside of the box (in exposed locations). Identify each pull and junction box with a system description as follows:
1. Lighting – Ltg, Panel, Ckt
 2. Receptacles – Rec, Panel, Ckt
 3. Equipment – Equipment ID, Panel, Ckt
 4. Fire Alarm – FA, Panel, Ckt

END OF SECTION 26 0553

SECTION 26 0573 - POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Short circuit analysis
- B. Overcurrent protective device settings

1.2 RELATED SECTIONS

- A. Refer to Section 260101 – Basic Electrical Requirements

1.3 REFERENCES

- A. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
- B. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
- C. IEEE 399 - Recommended Practice for Industrial and Commercial Power Systems Analysis
- D. NFPA 70 – National Electrical Code, latest version
- E. NFPA 70E – Standard for Electrical Safety in the Workplace
- F. Washington Administrative Code

1.4 SCOPE

- A. The Contractor shall employ the services of a skilled specialist to perform the following studies:
 - 1. Short Circuit Analysis
- B. The study shall be accomplished using computer software especially developed for this purpose. Manual studies will not be accepted.
- C. The short circuit analysis shall include the following portions of the electrical distribution system:
 - 1. Primary side of pad mounted service transformers.

2. Service entrance, main and distribution switchboards, generator, dry-type transformers, distribution and branch circuit panels, and associated feeders.
 3. Building motor contributions.
- D. Analysis shall be based upon connections which result in maximum fault conditions.
- E. Furnish a written report complete with fault current calculations and recommended adjustment settings based on the information provided in the report.
- F. Once the conduit and wiring system is installed, re-confirm the appropriate calculations to assure proper resolution and rating of downstream protective devices based on actual conductor lengths and other 'as installed' considerations. Replace such devices as may be necessary to assure the installed system is in complete compliance with the above studies/reports.

1.5 SUBMITTALS FOR REVIEW

- A. Credentials: Submit credentials of the individual performing the study and background information about the firm employed. The credentials shall be submitted prior to beginning work on the study and within 30 days of contractor's receipt of a notice to proceed.
1. The study shall be performed, stamped and signed by a professional engineer registered in the State of Washington. A minimum of five (5) years experience in medium and low voltage power system analysis is required for the individual in charge of performing the study.
- B. Preliminary Report: Submit a preliminary report to the Engineer for review and comment before releasing the distribution equipment for manufacture and within 90 days of contractor's receipt of a notice to proceed. The studies must be sufficiently complete to ensure that the selected devices have ratings and characteristics that will be satisfactory to provide system coordination. Resolve any comments and resubmit the preliminary report within 30 days following receipt of Engineer's comments.
- C. Final Report: Submit a final report to the Engineer for review and comment prior to delivery of the distribution equipment to the site. The Final Report shall include any adjustments to the studies, ratings, sizes, settings, placards, etc resulting from the final measurement of lengths and other field specific system parameters.
- D. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- E. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 INFORMATION FOR O&M MANUAL

- A. Final Study Report: Include two printed copies of the Final Report and two CDs containing the report plus all calculations, tabulations, descriptions and other materials including all ratings, sizes, settings, placards, etc

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE:

- A. Software Providers: Subject to compliance with these specifications, companies offering computer software that may be employed to accomplish the work of this section include:
 - 1. CYME International, Inc
 - 2. EDSA Micro Corporation
 - 3. Electrical Systems Analysis, Inc
 - 4. SKM Systems Analysis, Inc
 - 5. Or equivalent acceptable to the Engineer
- B. Software shall report device settings and ratings of all overcurrent protective devices.

2.2 STUDY REPORT

- A. The results of the power system studies shall be summarized in a bound study report. Multiple copies of the final report shall be furnished and included in the O&M Manuals.
- B. The report shall include the following sections:
 - 1. Project description, purpose, basis and scope of the study.
 - 2. Fault current calculations and indication that with the recommendations included in the study, the equipment will be properly rated and provided such that it will continue to operate properly following a maximum fault current episode.
 - 3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties, and commentary regarding the same.
 - 4. Tabulations of relay and circuit breaker trip settings, fuse selections, and commentary regarding the same.

PART 3 - EXECUTION

3.1 DATA COLLECTION

- A. The Contractor shall be responsible to obtain all required data necessary for the required studies.

3.2 SHORT CIRCUIT ANALYSIS

- A. The short circuit analysis shall be performed with the aid of a computer and a suitable software package.
- B. The rationale and assumptions employed in developing the calculations shall be incorporated in the introductory remarks of the study.
- C. The study shall include a computer printout of input circuit data including conductor lengths, number of conductors per phase, conductor impedance values, insulation types, transformer impedances and X/R ratios, motor contributions, and other circuit information as related to the short-circuit calculations.
- D. Source Impedance:
 - 1. As determined from the generator vendor.
 - 2. As an infinite bus on the primary side of each pad mounted distribution transformer.
- E. Determine the available 3-phase short circuit and ground fault currents at each bus. Incorporate the motor contribution, applying motor contribution at the appropriate locations in the system.
 - 1. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed 3-phase bolted fault.
 - 2. Calculate ground fault current, including the associated zero sequence impedance data.
- F. Present the data determined by the short circuit study in tabular format. Include:
 - 1. Node & Device identification
 - 2. Operating voltage at each node
 - 3. Type of protective device upstream of each node
 - 4. Equipment short circuit rating at each node
 - 5. Maximum 3-phase short circuit current, at each node, asymmetrical and symmetrical, together with X/R ratio.
 - 6. Maximum arcing ground fault current at each node where line-to-ground voltage exceeds 120 volts, and together with zero-sequence impedance data.
 - 7. Comments section indicating whether devices are properly rated. De-rate the devices where the tested X/R ratio is less than the calculated X/R ratio.
- G. Include a comprehensive discussion section evaluating the adequacy of the distribution equipment. Make recommendations as appropriate for improvements to the system.

3.3 OVER-CURRENT PROTECTIVE DEVICE SETTING

- A. Model the entire electrical distribution system and run load flow analysis for all operating scenarios.
- B. Engage a factory-authorized service representative, to set overcurrent protective devices within equipment in accordance with the results of the study. If study recommends different

type of devices or equipment, provide it at no additional cost. Provide a written report which itemizes each setting applied to each device. Include device name, setting value, date, time and name of individual performing settings.

- C. Testing: Perform the following device setting and prepare reports:
- D. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:
 - 1. Verify that overcurrent protective devices meet parameters used in studies.
 - 2. Adjust devices to values listed in study results.
 - 3. Adjust devices according to codes and manufacturers recommendations.

3.4 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections."

END OF SECTION 26 0573

SECTION 26 0800 - ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Electrical system specific commissioning
- B. Related Sections:
 - 1. Division 26

PART 2 - EXECUTION

2.1 SYSTEMS READINESS CHECKLISTS

- A. Review and Complete Systems Readiness Checklists in accordance with Section 260800.
- B. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
- C. The initial Systems Readiness Checklists are provided elsewhere in this section of the contract documents. The final checklists may be modifications of the initial checklists, and checklists may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
- D. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work.
- E. The Systems Readiness Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere

2.2 SYSTEMS READINESS PLAN

- A. The Contractor shall provide a system readiness manual, which shall include the following:
 - 1. Systems Readiness Checklists – provided by CxA and completed by the Contractor
 - 2. Startup and testing procedures and data forms, in accordance with the project specifications, for all equipment and systems within the commissioning scope of work

- B. Within 20 working days of Product Submittal approval, submit the Systems Readiness Plan with blank forms for CxA review.
- C. Submit the completed readiness manual prior to functional performance testing. When it is necessary to begin functional performance testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the Systems Readiness Plan that have been completed only for the system(s) that are ready for testing.

2.3 FUNCTIONAL PERFORMANCE TESTING

- A. The Functional Performance Test (FPT) Procedures shall be developed, performed, and demonstrated.
- B. At a minimum, the contractors and equipment suppliers listed in the FPTs Minimum Participants Table in this section of the specifications are required to participate in developing, performing, and demonstrating the indicated FPTs.
- C. The Contractor's Commissioning Coordinator shall coordinate the subcontractors, with the Commissioning Authority's input, in developing, performing, and demonstrating the Working FPT.
- D. Functional testing shall consist of the following four phases:
 - 1. Component testing:
 - a. Component testing applies to all control input and output devices, including those provided the equipment suppliers and those provide with the Building Management System (BMS). Examples include but are not limited to: photo-sensors, occupancy switches, ballasts, meters, etc.
 - b. Component testing consists of demonstrating field I/O calibration and operation including but not limited to:
 - 1) Accuracy and settings of sensors and input devices is within specified range.
 - 2) Output devices operate smoothly in a linear relationship with the signal they receive, over the full range of operation
 - 3) Fail safe operation of components and controllers is as specified for loss of control signal, electric power, and network communications
 - 4) All input and output devices are correctly mapped to operator interface
 - 2. Systems Testing; Operational Verification: After functional testing of the system components has been successfully completed, each sequence of operation and control system function shall be functionally tested, including those provided the equipment suppliers. Each control loop shall be tested to verify stable control with the specified and appropriate responses.
 - 3. Systems Testing – Integrated System Verification: After operational testing has successfully demonstrated that each system functions in accordance with the project documents, functional testing shall occur to verify that the interaction between the

systems is as required. Each interactive function shall be functionally tested, including those provided the equipment suppliers.

E. FPTs Minimum Participants Table:

- EC = Division 26 (Electrical) subcontractor,
- EP = Emergency Power Equipment Supplier and Startup Technician
- FA = Fire Alarm System subcontractor, Technician.
- S = Security System subcontractor, Technician.
- BAS = Section 230923 Energy Management and Control System subcontractor,

FPT (SPEC) NUMBER	FPT	MINIMUM PARTICIPANTS
	INTER-SYSTEM TESTS	
CC-2.0	Fire System Shutdown - DDC	EC, BAS, FA

2.4 SYSTEMS READINESS CHECKLISTS:

- A. Shall be created by the CxA and given to the contractors at the Construction Phase Cx Kickoff meeting and after the approved equipment submittals have been returned by the Design Team to the contractors.

2.5 FUNCTIONAL PERFORMANCE TEST PROCEDURES:

- A. Shall be created by the CxA and given to the contractors for review after the approved equipment submittals have been returned by the Design Team to the contractors. After written acceptance from the contractors the final tests will be distributed to the contractors prior to equipment start-up.

END OF SECTION 26 0800

SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Distribution panelboards
- B. Branch circuit panelboards

1.2 RELATED SECTIONS

- A. Section 260526 - Grounding and Bonding
- B. Section 260553 - Electrical Identification
- C. Section 262813 – Fuses
- D. Section 260549 - Seismic Controls for Electrical

1.3 REFERENCES

- A. NEMA PB 1 - Panelboards
- B. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
- C. UL 50 - Cabinets and Boxes
- D. UL 67 - Panelboards
- E. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures
- F. UL 943 - Ground-Fault Circuit Interrupters

1.4 SCOPE OF WORK

- A. The information within this specification applies to modifications on existing equipment. Where such work is performed, new equipment shall be of same manufacturer and compatible with the ratings and size of the equipment where installed.

1.5 SUBMITTALS FOR REVIEW

- A. Product Data: Submit information covering equipment to be provided on the project, as follows: descriptive bulletins; voltage; overcurrent device interrupting capacity ratings; conductor terminal sizes; and accessories.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.6 PROJECT FINALIZATION

- A. Submit under provisions of Section 260102.
- B. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- C. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with the manufacturer.

1.7 RECORD DOCUMENTS

- A. Record actual circuiting arrangements.

1.8 REGULATORY REQUIREMENTS

- A. Products: Devices shall be UL listed and classified as suitable for the purpose indicated.

1.9 WARRANTY

- A. Submit under provisions of Section 260102.
- B. Products furnished under this section shall be guaranteed against defective parts or workmanship for a period of one year after the date of substantial completion. The guarantee shall cover full parts and labor.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. Manufacturers: Square D.

- B. Interiors: Circuit breakers shall match panelboard interior type..

2.2 DISTRIBUTION PANELBOARDS

- A. Bolt-On Alternative: In lieu of bolt-on circuit breakers, circuit breakers equipped with line terminal jaws, equal to Square D I-Line type, are acceptable, provided that in the event of a short circuit condition, the increased magnetic flux causes the jaws to grip the bus more firmly. Circuit breaker jaws shall be protected by an impact resistant molded shroud. Circuit breakers of this type shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners.

2.3 BRANCH CIRCUIT PANELBOARDS

- A. Panel Index: An updated directory card with a clear plastic cover shall be supplied and mounted on the inside of each door.

2.4 SHORT CIRCUIT RATINGS

- A. Overcurrent protective devices shall have the interrupting capacity rating as indicated without relying upon series-connected ratings.

2.5 CIRCUIT BREAKERS

- A. Circuit breakers shall be molded-cast type, with inverse time and instantaneous tripping characteristics.
- B. Each circuit breaker shall be operated by a single toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position. Contacts shall be non-welding with arc extinction chutes. Multiple-pole circuit breakers shall be common trip.
- C. Where indicated, circuit breakers shall be current-limiting type. Such circuit breakers shall have automatically resetting current limiting elements in each pole, coordinated with the thermal and instantaneous trip elements. Let-through current and energy level shall be less than permitted for same size Class RK5 fuse.
- D. The trip rating of each circuit breaker shall be imprinted in the handle.
- E. Ground fault interrupting circuit breakers shall have "Test" button and pigtail for neutral connection.
- F. Circuit breakers located in non-air-conditioned spaces or outside the building shall be ambient compensated type.
- G. Circuit breakers used for air conditioning equipment shall be UL labeled "HACR".
- H. Circuit breakers shall have mechanical screw type removable connector lugs, AL/CU rated.

- I. Circuit Breaker Accessories: Provide shunt-trip units and auxiliary switches as indicated on the drawings or panel schedules.

2.6 FUSIBLE SWITCH ASSEMBLIES

- A. Fusible switches shall be quick-make, quick-break, load interrupter enclosed knife switches with externally operable handles. Provide interlock with defeat mechanism to prevent opening front cover with switch in ON position. Handle shall be lockable in OFF position.
- B. Fusible switches shall be equipped with rejection-type fuse clips designed to accommodate Class R current-limiting fuses only, except as otherwise indicated.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Field Measurement: Verify that equipment will fit in the available.

3.2 DELIVERY, STORAGE AND HANDLING

- A. Inspect and report concealed damage to carrier within their required time period. Damaged equipment shall be replaced or repaired prior to installation.
- B. Handle carefully to avoid damage to components.
- C. Store in a clean, dry environment. Maintain factory packaging. If required to protect equipment from dirt, water, construction debris and traffic, provide an additional heavy canvas or heavy plastic cover.

3.3 INSTALLATION

- A. Circuit breakers shall be arranged to reflect the size and order shown on the panel schedules.
- B. Provide filler plates for unused spaces in panelboards.
- C. Neatly arrange and lace conductors in panelboards, gutters and terminal cabinets by means of nylon twine or wraps.
- D. Provide a typewritten circuit directory for each branch circuit panelboard. Directory cards shall be completely filled out with all circuits adequately marked. Spares shall be marked "Spare" in pencil. Directory cards shall indicate load served and room number for each circuit. The permanent room numbers, assigned by the Owner, shall be used on the directory cards. The Contractor shall verify the loads served by each existing circuit. Revise directories to reflect any circuiting changes.
- E. Equipment shall be clean at time of final inspection by owner.

- F. Provide seismic controls in accordance with 260549.

3.4 ADJUSTMENT AND TESTING

- A. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's instructions.
- B. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.
- C. Measure steady state load currents at each panelboard feeder. If necessary, rearrange circuits in the panelboard to balance the phase loads to within 20 % of each other. Maintain proper phasing for multi-wire branch circuits.
- D. Upon completion of the above adjustment and testing, the Contractor shall energize the system and demonstrate proper operation of all equipment in the presence of the Owner's representative. Notify Owner's representative at least one (1) week in advance of the dates when the demonstration will be undertaken. Demonstration shall include:
 - 1. Apparatus arranged for manual operation shall be operated under power then returned to their normal position.
 - 2. Operation of control equipment to verify that it operates properly. Tests of control equipment shall include at least two operating cycles.
- E. Any deficiencies discovered as a result of the above tests shall be rectified and the work affected by such deficiencies shall be completely retested at the Contractor's expenses.
- F. Instruments, gauges, testing equipment, protective devices and safety equipment for all testing shall be provided by the Contractor. Energy for the tests will be furnished by the Owner.

3.5 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections."

3.6 TRAINING

- A. The Contractor shall provide one (1) hour minimum of training for maintenance personnel in the maintenance and operation of the equipment. Training shall also cover maintenance and operation of other similar equipment, including enclosed circuit breakers and safety switches.
- B. A training plan shall be submitted in advance for approval, outlining the topics to be covered, the publications to be used, and the training schedule.
- C. The training shall be conducted by personnel thoroughly familiar with the equipment and its features. The training shall include instruction and over-the-shoulder hands-on training. As a minimum, the training shall cover:
 - 1. Recommended maintenance procedures and intervals.
 - 2. Operation of all control equipment to demonstrate that it operates in accordance with the requirements of this section.

END OF SECTION 26 2416

SECTION 26 2716 - CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Hinged cover enclosures
- B. Cabinets
- C. Accessories

1.2 RELATED SECTIONS

- A. Section 262727 - Supporting Devices

1.3 REFERENCES

- A. NECA Standard of Installation (National Electrical Contractors Association)
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- C. NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Product Data: Provide manufacturer's standard data for enclosures, cabinets, terminal blocks, and accessories.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.5 REGULATORY REQUIREMENTS

- A. Products: Listed and classified by Underwriters Laboratories, Inc. or other testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 CABINETS AND HINGED COVER ENCLOSURES

- A. Manufacturers:
 - 1. Circle AW
 - 2. Hoffman
 - 3. Rittal
 - 4. Or approved equal
- B. Construction: NEMA 250, Type 1 steel enclosure, unless otherwise indicated.
- C. Size: As indicated on the drawings. If not so indicated, sized to accommodate devices within.
- D. Covers: Continuous hinge, and flush lock keyed to match branch circuit panelboard.
- E. Interior Panels: Provide 14 gauge, white enamel, and removable panels for mounting of equipment or terminal blocks.
- F. Knockouts: Manufacturer's standard knockouts.
- G. Enclosure Finish: Manufacturer's standard gray baked enamel.
- H. Provide metal barriers to form separate compartments wiring of different systems and voltages.
- I. Provide accessory feet for free-standing equipment.

2.2 FABRICATION

- A. Shop assemble enclosures and cabinets housing terminal blocks or electrical components in accordance with ANSI/NEMA ICS 6.
- B. Provide conduit hubs in exterior and wet locations and knockouts in interior dry locations.
- C. Provide protective pocket inside front cover with schematic diagram, connection diagram, and layout Drawing of control wiring and components within enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with NECA "Standard of Installation."
- B. Install enclosures and boxes plumb. Anchor securely to wall and structural supports at each corner under the provisions of Section 262727.

- C. Install cabinet fronts plumb.

3.2 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

3.3 CLEANING

- A. Clean electrical parts to remove conductive and harmful materials.
- B. Remove dirt and debris from enclosure.
- C. Clean finishes and touch up damage.

END OF SECTION 26 2716

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Receptacles
- B. Device plates

1.2 RELATED SECTIONS

- A. Section 260532 - Boxes

1.3 REFERENCES

- A. NECA - Standard of Installation
- B. NEMA WD 1 - General Requirements for Wiring Devices
- C. NEMA WD 6 - Wiring Device - Dimensional Requirements
- D. NFPA 70 - National Electrical Code

1.4 SUBMITTALS FOR REVIEW

- A. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

- A. Provide products listed and classified by Underwriters Laboratories, Inc., as suitable for the purpose specified and indicated.

1.7 EXTRA MATERIALS

- A. Furnish two of each style, size, and finish wall plate.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

- A. Wiring devices shall be of the same manufacturer insofar as possible. Devices shall be specification grade, rated minimum 20 amperes. Receptacles shall be grounding type.
- B. Devices shall be side wired only.
- C. Except as otherwise specified on the drawings, wiring devices shall be Hubbell, Pass & Seymour, Cooper, or Leviton and shall be in accordance with the following schedule:

DEVICE	HUBBELL CATALOG #	PASS & SEYMOUR CATALOG #	COOPER CATALOG #	LEVITON CATALOG #
DUPLEX RECEPTACLE, GFI	GF20	2095	VGF20	7899
2 POLE SWITCH	1222	20AC2 CPL	2221PL	1221 PLC

- D. Standard wiring device colors shall be as selected by the Owner. Receptacles served from Generator or Backup power sources shall be RED in color.
- E. Weatherproof devices shall be the same as standard devices except with diecast lockable weatherproof plate equal to Intermatic #WP1010HMC.
- F. Ground fault interrupting receptacles shall be duplex type with "Test" and "Reset" buttons. Receptacle shall have feed-through provisions for protection of downstream receptacles. Unit shall be complete with cover plate. Receptacles located on the building exterior, in toilet rooms, and elsewhere as shown on the drawings shall be GFI type. Provide cast weatherproof cover plates with hinge on top for receptacles on the building exterior.

2.2 DEVICE PLATES

- A. Generally, devices and blanked outlet boxes shall have stainless steel plates equal to Sierra S-Line. Stainless steel plates shall be 0.04 inch thick with #302 satin finish. Where required by the Owner, colored plastic faceplates shall be provided for devices.

- B. Device plates for outlets shall be identified with its corresponding panel and circuit designation. Flexible nylon tape labels are acceptable for identification of outlets. Nylon labels shall be clear with black lettering for stainless device plates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that outlet boxes are installed at proper height.
- B. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- C. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean debris from outlet boxes.

3.3 INSTALLATION

- A. Install all receptacles with the use of wiring pigtails.
- B. Install devices plumb and level.
- C. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
- D. Unless otherwise indicated, receptacles shall be oriented vertically. Weatherproof receptacles shall be mounted horizontally with the hinge at the top.
- E. Where vertically oriented, receptacles shall be installed with the grounding slot at the top. Where horizontally oriented, receptacles shall be installed with the grounding slot to the right.
- F. Wiring shall be connected to the side wiring terminals on wiring devices.

3.4 FIELD QUALITY CONTROL

- A. Inspect each wiring device for defects.
- B. Verify that each receptacle device is energized.
- C. Test each receptacle device for proper polarity.

- D. Test each GFCI receptacle device for proper operation.

3.5 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

3.6 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

3.7 CLEANING

- A. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION 26 2726

SECTION 26 2727 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Conduit and equipment supports
- B. Anchors and fasteners

1.2 REFERENCES

- A. NECA Standard of Installation (National Electrical Contractors Association)
- B. NFPA 70 - National Electrical Code

1.3 SUBMITTALS FOR REVIEW

- A. Submit under provisions of Section 260102.
- B. Product Data: Provide manufacturer's catalog data for fastening systems.
- C. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- D. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.

1.4 PROJECT FINALIZATION

- A. Submit under provisions of Section 260102.
- B. Operation and Maintenance Data: Include manufacturer's descriptive literature, installation instructions, maintenance and repair data, and parts listing.

1.5 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A. Materials and Finishes: Corrosion resistant.
- B. Select materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit, including weight of wire in conduit.
- C. Anchors and Fasteners:
 - 1. Concrete Structural Elements: Use precast inserts, expansion anchors and preset inserts.
 - 2. Steel Structural Elements: Use beam clamps, spring steel clips, and welded fasteners.
 - 3. Concrete Surfaces: Use self drilling anchors and expansion anchors.
 - 4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts and hollow wall fasteners.
 - 5. Solid Masonry Walls: Use expansion anchors and preset inserts.
 - 6. Sheet Metal: Use sheet metal screws with square drive heads.
 - 7. Wood Elements: Use wood screws with square drive heads.

2.2 FORMED STEEL CHANNEL

- A. Manufacturers:
 - 1. B-Line or equal
- B. Description: Galvanized steel or zinc plated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locate and install anchors, fasteners, and supports in accordance with NECA "Standard of Installation".
 - 1. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
 - 2. Do not drill or cut structural members.
 - 3. Obtain permission from Engineer before drilling or cutting structural members.
- B. Fabricate supports from structural steel or formed steel members. Rigidly weld members or use hexagon-head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
- C. Secure floor mounted equipment to floor with machine bolts and anchors in accordance with the manufacturer's recommendations and seismic requirements.

- D. Install surface-mounted cabinets and panelboards with minimum of four (4) anchors. Cabinets and panelboards shall not be secured to hollow masonry, plaster, or gypsum board partitions - provide additional blocking as required between studs to securely anchor the cabinet or panelboard.
- E. In wet and damp locations use steel channel supports to stand cabinets and panelboards 1 inch off wall.
- F. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.
- G. Where one hole straps are used for horizontal conduit runs, locate screw on the bottom side of the conduit.

3.2 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

END OF SECTION 26 2727

SECTION 26 2813 - FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Fuses for use in power distribution circuits

1.2 RELATED SECTIONS

- A. Section 262816 – Enclosed Switches

1.3 REFERENCES

- A. NEMA FU1 - Low Voltage Cartridge Fuses
- B. UL 50 - Enclosures for Electrical Equipment
- C. UL 198C - High-Interrupting-Capacity Limiting Type Fuses
- D. UL 198D - High-Interrupting-Capacity Class K Fuses
- E. UL 198E - Class R Fuses
- F. UL 198H - Class T Fuses

1.4 SCOPE

- A. The Contractor shall provide fuses as indicated on the drawings and associated schedules.

1.5 SUBMITTALS FOR REVIEW

- A. Product Data: Submit information covering every type of fuse to be provided on the project as follows: Component list, descriptive bulletins, voltage, and interrupting capacity ratings.
- B. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- C. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.

1.6 INFORMATION FOR O & M MANUAL

- A. Submittals: Information submitted for review.

1.7 RECORD DOCUMENTS

- A. Record final fuse size used for each set of fuses.
- B. Record final location of spare fuse cabinet.

1.8 QUALITY ASSURANCE

- A. Products: Fuses shall be manufactured in accordance with the latest revision of NEMA FU1.

1.9 REGULATORY REQUIREMENTS

- A. Products: Fuses shall be UL listed and classified as suitable for the purpose indicated.

1.10 MAINTENANCE MATERIALS

- A. Provide 10 % spare fuses, but not less than three (3) of each size and type used on the project.
- B. Furnish two (2) fuse pullers of each type required to facilitate removal of fuses provided on project.

PART 2 - PRODUCTS

2.1 FUSES

- A. Manufacturers: Bussman, Shawmut, and Littlefuse.
- B. Fuses shall be provided as indicated on the drawings and shall be current-limiting type.
- C. Fuses in switchboards shall be Class L or Class J type, unless otherwise indicated on the drawings and/or associated schedules.
- D. Fuses in safety switches, busway plug-in units, and panelboards shall be Class RK1, unless otherwise indicated on the drawings and/or associated schedules.
- E. Fuses in combination motor starters and fuses protecting motors or transformers shall be Class RK5 dual-element time-delay type.
- F. Interrupting Capacity: 200,000 amperes RMS symmetrical.
- G. Provide one (1) complete set (3 per size) of spare fuses in a metal cabinet.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fuses in accordance with manufacturer's instructions.
- B. Install each fuse with label oriented such that manufacturer, type, and size are easily read.
- C. Install a nylon label on inside door of each fusible switch indicating fuse class and size installed.

3.2 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

END OF SECTION 26 2813

SECTION 26 2816 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Fusible switches
- B. Non-fusible switches

1.2 RELATED SECTIONS

- A. Section 262813 - Fuses

1.3 REFERENCES

- A. NEMA KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)
- B. UL 50 - Electrical Cabinets and Boxes
- C. UL 98 - Enclosed and Dead Front Switches
- D. UL 512 - Fuseholders
- E. UL 869 - Electrical Service Equipment

1.4 SCOPE

- A. The Contractor shall provide safety switches as indicated on the drawings and associated schedules.
- B. The Contractor shall adjust and test the safety switches.

1.5 SUBMITTALS FOR REVIEW

- A. Product Data: Submit information covering every type of fused switch to be provided on the project, as follows: component list; descriptive bulletins; voltage; ampere and horsepower ratings; and conductor terminal sizes.
- B. Shop Drawings: For each safety switch, show the following: outline and support points, with dimensions; location of neutral and ground buses; wiring gutter dimensions.

- C. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- D. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal.

1.6 INFORMATION FOR O&M MANUAL

- A. Submittals: Information Submitted for Review.
- B. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protections, examination, preparation and installation of product.
- C. Maintenance Data: Furnish the following information:
 - 1. Replacement parts listing, including source.
 - 2. Recommended maintenance procedures and intervals.

1.7 QUALITY ASSURANCE

- A. Products: Safety switches shall be designed and manufactured in accordance with the latest revision of NEMA KS1.

1.8 REGULATORY REQUIREMENTS

- A. Products: Safety switches shall be UL listed and classified as suitable for the purpose indicated.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. Manufacturers: Eaton Electrical, General Electric or Square D.
- B. Type: Safety switches shall be enclosed heavy-duty type, with externally operable handle and enclosed load-interrupter knife switch.
- C. Construction: Switch mechanism shall be quick-make quick-break type, such that the operation of the contacts shall not capable of being restrained by the operating handle after the closing or opening action of the contacts has started.
 - 1. The handle shall travel at least 90 degrees between ON and OFF positions so the handle position is easily recognizable. Facilities shall be provided for padlocking handle in OFF position.
 - 2. Switches shall have defeatable door interlocks that prevent the door from opening when the operating handle is in the ON position.

3. Switches shall have line terminal shields.
 4. Current carrying parts shall be plated to resist corrosion.
 5. Switches shall have removable arc suppressors to facilitate easy access to line side lugs.
- D. Neutral Bus: A full-size insulated neutral bus shall be included in safety switches indicated with neutral. Neutral busing shall have suitable lugs for each incoming and outgoing circuit requiring a neutral connection.
- E. Ground Bus: A copper ground bus capable of being isolated shall be included in each safety switch. The ground bus shall be bonded to the switch enclosure. Ground busing shall have suitable lugs for the equipment grounding conductors associated with the incoming and outgoing circuits and for any bonding conductors.
- F. Enclosures: Rated to suit the installation location. Indoor switches shall have NEMA Type 1 general purpose enclosures, except as otherwise indicated on the drawings. Unless otherwise indicated, switches installed outdoors shall have NEMA Type 3R raintight enclosures.
1. Enclosures shall be made from galvanized steel.
 2. Provide adequate gutter space for wire bending and termination. Where conductors supplying a safety switch are carried through its enclosure to supply other electrical equipment, the enclosure shall be sized to include the additional required wiring space.

2.2 FUSIBLE SWITCHES

- A. Fuse Clips: Fusible switches shall be equipped with rejection-type fuse clips designed to accommodate Class R current-limiting fuses only, except as otherwise indicated.
- B. Service Equipment: Fusible switches used as service-entrance equipment shall be UL listed and labeled as suitable for such use.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Field Measurement: Verify that field measurements are as indicated and that equipment will fit in the available space while maintaining required working space clearances.

3.2 DELIVERY, STORAGE AND HANDLING

- A. Inspect and report concealed damage to carrier within their required time period. Damaged equipment shall be replaced or repaired prior to installation.
- B. Handle carefully to avoid damage to safety switch internal components, enclosure, and finish.

- C. Store in a clean, dry environment. Maintain factory packaging. If required to protect equipment from dirt, water, construction debris, and traffic, provide an additional heavy canvas or heavy plastic cover.

3.3 INSTALLATION

- A. Install safety switches in accordance with manufacturer's instructions.
- B. Install safety switches plumb. Anchor safety switches to structure.
- C. Mount safety switches with top of operating handle 54 inches above floor when in its highest position, except as otherwise indicated. In no case shall the handle be mounted more than 78 inches above the floor when in its highest position.
- D. Neatly arrange and lace conductors in safety switch enclosures by means of nylon twine or wraps.
- E. Apply adhesive tag on inside door of each fusible switch indicating fuse class and size installed.

3.4 ADJUSTMENT AND TESTING

- A. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Check tightness of bolted connections using calibrated torque wrench or torque screwdriver per manufacturer's instructions.
- B. Inspect complete installation for physical damage, proper alignment, anchorage and grounding.
- C. Upon completion of the above adjustment and testing, the Contractor shall energize the system and demonstrate proper operation of all equipment in the presence of the Owner's representative. Notify Owner's representative at least one week in advance of the dates when the demonstration will be undertaken. Demonstration shall include:
 - 1. Apparatus arranged for manual operation shall be operated under power then returned to their normal position.
- D. Any deficiencies discovered as a result of the above tests shall be rectified and the work affected by such deficiencies shall be completely retested at the Contractor's expense.
- E. Instruments, gauges, testing equipment, protective devices and safety equipment for all testing shall be provided by the Contractor. Energy for the tests will be furnished by the Owner.

3.5 COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

END OF SECTION 26 2816

SECTION 26 2817 - ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Molded-case enclosed circuit breakers

1.2 RELATED SECTIONS

- A. Section 260553 - Electrical Identification: Engraved nameplates
- B. Section 262727 - Supporting Devices

1.3 REFERENCES

- A. NEMA AB1 - Molded Case Circuit Breakers
- B. UL 50 - Enclosures for Electrical Equipment
- C. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures
- D. UL 869 - Electrical Service Equipment
- E. UL 943 - Ground-Fault Circuit Interrupters

1.4 SCOPE

- A. The Contractor shall provide enclosed circuit breakers as indicated on the drawings and associated schedules.
- B. The Contractor shall adjust and test the enclosed circuit breakers.

1.5 SUBMITTALS FOR REVIEW

- A. Product Data: Submit information covering every type of enclosed circuit breaker to be provided on the project, as follows: Component list, descriptive bulletins, voltage, interrupting capacity ratings, conductor terminal sizes, trip units, if applicable, and accessories.
- B. Shop Drawings: For each enclosed circuit breaker, show the following: Outline and support points, with dimensions, location of neutral and ground buses, and wiring gutter dimensions.

1.6 PROJECT FINALIZATION

- A. Submit under provisions of Section 260102.
- B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- C. As-Built Drawings: Record final location of each enclosed circuit breaker.
- D. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with the manufacturer.

1.7 QUALITY ASSURANCE

- A. Products: Circuit Breakers shall be manufactured in accordance with the latest revision of NEMA AB1.

1.8 REGULATORY REQUIREMENTS

- A. Products: Enclosed circuit breakers shall be UL listed and classified as suitable for the purpose indicated.

1.9 WARRANTY

- A. Submit under provisions of Section 260102.
- B. The enclosed transfer switch furnished under this section shall be guaranteed against defective parts or workmanship for a period of one year after the date of substantial completion. The guarantee shall cover full parts and labor.

PART 2 - PRODUCTS

2.1 GENERAL DESCRIPTION

- A. Manufacturers: Square D.
- B. Type: Enclosed circuit breakers shall be provided with dead-front enclosures. The circuit breaker handle or operating mechanism shall be accessible through the front cover.
- C. Neutral Bus: A full-size insulated neutral bar shall be included in each enclosed circuit breaker indicated with neutral. Neutral busing shall have suitable lugs for all incoming and outgoing circuits requiring a neutral connection.
- D. Ground Bus: A copper ground bus capable of being isolated shall be included in each enclosed circuit breaker. The ground bus shall be bonded to the enclosure, except where ground bus is

indicated to be isolated. Ground busing shall have suitable lugs for the equipment grounding conductors associated with all incoming and outgoing circuits and for any bonding conductors.

- E. Enclosures: Enclosures shall be suitable for locations as indicated on the drawings. Except as otherwise indicated, enclosures located indoors shall be NEMA Type 1 general purpose enclosures, and enclosures located outdoors shall be NEMA Type 3R rain-tight enclosures.
 - 1. Enclosed circuit breakers shall be surface-mounted or flush-mounted as indicated. Surface trims shall be same height and width as box. Flush trims shall overlap the box by $\frac{3}{4}$ inch on all sides.
 - 2. Enclosures shall be made from galvanized steel. Provide adequate gutter space for wire bending and termination. Where conductors supplying the enclosed circuit breaker are carried through its box to supply other electrical equipment, the enclosure shall be sized to include the additional required wiring space.
- F. Finish: In finished areas, finish enclosed circuit breakers with one coat of zinc chromate and one coat of primer sealer. In all other locations, finish enclosed circuit breakers with one coat of zinc chromate and one coat of gray baked enamel.
- G. Service Equipment: Enclosed circuit breakers used as service-entrance equipment shall be UL listed and labeled as suitable for such use.

2.2 SHORT CIRCUIT RATINGS

- A. Each enclosed circuit breaker shall be labeled with a UL integrated equipment short circuit rating. All circuit breakers shall have the interrupting capacity rating as indicated without relying upon series-connected ratings, except as otherwise specifically indicated on the drawings and/or associated schedules.
- B. Enclosed circuit breakers applied at 240 volts or less shall have short circuit ratings as indicated on the drawings and/or associated schedules, but not less than 10,000 amperes RMS symmetrical.
- C. Enclosed circuit breakers applied at 480 volts or less shall have short circuit ratings as indicated on the drawings and/or associated schedules, but not less than 14,000 amperes RMS symmetrical.
- D. When series ratings are indicated on the drawings and/or associated schedules, a UL series-rating label shall be provided. The label shall state the conditions of the UL series rating, including:
 - 1. Size and type of required upstream device
 - 2. UL series short circuit rating

2.3 CIRCUIT BREAKERS

- A. Circuit breakers shall be molded-case type, with inverse time and instantaneous tripping characteristics.

- B. Each circuit breaker shall be operated by a single toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle positions. Contacts shall be non-welding silver alloy type with arc extinction chutes. Multiple-pole circuit breakers shall be common trip.
 - C. Where indicated, circuit breakers shall be current-limiting type. Such circuit breakers shall have automatically-resetting current limiting elements in each pole, coordinated with the thermal and instantaneous trip elements. Let-through current and energy level shall be less than permitted for same size Class RK-5 fuse.
 - D. The trip rating of each unit shall be clearly indicated and visible or identified on a permanently affixed nameplate. Adjustments shall be accessible without removing covers, unless such removal does not require use of tools.
 - E. Where serving NEC 700 or 702 systems, circuit breakers shall be equipped with a tripping system consisting of three (3) current sensors, a trip unit, and a flux-transfer shunt trip. The trip unit shall provide adjustable time-current protection functions. Interchangeable rating plugs shall establish the continuous trip ratings of each circuit breaker. The trip unit shall include adjustments for:
 - 1. Long-time pick-up and delay
 - 2. Short-time pick-up and delay, with I²t curve-shaping option
 - 3. Instantaneous pick-up
 - F. The trip rating of the circuit breakers shall be imprinted in the handle.
 - G. Ground fault interrupting circuit breakers shall have "Test" button and pigtail for neutral connection.
 - H. Circuit breakers located in non-air-conditioned spaces or outside the building shall be ambient compensated type.
 - I. Circuit breakers used for air conditioning equipment shall be UL labeled "HACR".
 - J. Circuit breakers shall have mechanical screw type removable connector lugs, AL/CU rated.
- 2.4 ACCESSORIES
- A. Handle Lock: Enclosed circuit breakers shall include provisions for padlocking.
 - B. Provide kirk-key interlocks, shunt trips, and auxiliary switches as indicated on the drawings.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Field Measurement: Verify that field measurements are as indicated and that the equipment will fit in the available space while maintaining required working clearances.

3.2 DELIVERY, STORAGE AND HANDLING

- A. Inspect and report concealed damage to carrier within their required time period. Damaged equipment shall be replaced or repaired prior to installation.
- B. Handle carefully to avoid damage to enclosed circuit breaker internal components, enclosure and finish.
- C. Store in a clean, dry environment. Maintain factory packaging. If required to protect equipment from dirt, water, construction debris and traffic, provide an additional heavy canvas or heavy plastic cover.

3.3 INSTALLATION

- A. Install enclosed circuit breakers in accordance with manufacturer's instructions.
- B. Install enclosed circuit breakers plumb. Recessed enclosed circuit breakers shall be installed flush with wall surface. Anchor enclosed circuit breakers to structure.
- C. Mounting Height: 60 inches to operating handle.
- D. Neatly arrange and lace conductors in enclosures by means of nylon twine or wraps.

3.4 ADJUSTMENT AND TESTING

- A. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench for torque screwdriver per manufacturer's instructions.
- B. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.
- C. Adjust trip settings so that circuit breakers coordinate with other overcurrent protective devices in circuit, yet provide adequate protection from overcurrent and fault currents.
- D. Upon completion of the above adjustment, the Contractor shall energize the system and demonstrate proper operation of all equipment and materials in the presence of the Owner's representative. Notify Owner's representative at least one (1) week in advance of the dates when the above demonstration will be undertaken. Demonstration shall include:

1. Apparatus arranged for manual operation shall be operated under power then returned to their normal position.
 2. Operate all control equipment and verify that it operates properly. Tests of control equipment shall include at least two operating cycles.
- E. Deficiencies discovered as a result of the above tests shall be rectified and the work affected by such deficiencies shall be completely retested at the Contractor's expenses.
- F. Instruments, gauges, testing equipment, protective devices and safety equipment for all testing shall be provided by the Contractor. Energy for the tests will be furnished by the Owner.

END OF SECTION 26 2817

SECTION 28 3110 - FIRE ALARM SYSTEMS (SIMPLEX)

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Fire Alarm System

1.2 RELATED SECTIONS

- A. Section 260530 - Conduit

1.3 SYSTEM DESCRIPTION

- A. The information within this specification applies to modifications on existing equipment. Where such work is performed, new equipment shall be of same manufacturer and compatible with the ratings and size of the equipment where installed. Provide modifications to the Fire Alarm System as described herein. Include duct smoke detectors, associated relay devices, and reprogramming of the FACP as needed.

1.4 POWER REQUIREMENTS

- A. Provide Simplex #2081-9028 Isolated Loop Circuit Protectors (ICLP) on communication, addressable, SCU/RCU, initiating, indicating, and signaling lines, including shields, on all circuits that extend beyond the building by any means.

1.5 QUALITY ASSURANCE

- A. Items of the Fire Alarm System shall be listed under the appropriate category by Underwriters Laboratories, Inc. (UL) and bearing the "UL" label. Provide control equipment that is all listed under UL category UOJZ as a single control unit. Partial listing is NOT acceptable.
- B. Provide Fire Alarm System components that are the products of a single manufacturer (independent dealers and/or distributors will NOT be considered). The manufacturer must have engaged in the production of this type of equipment (software driven) for at least 10 years, and have a fully equipped service organization within two hundred (200) miles of this installation. The supplier's technicians performing the panel terminations, programming, startup, checkout, and acceptance testing shall be factory trained and certified to perform such activities. This individual must possess at a minimum Level II certification from NICET in the Fire Alarm System field.
- C. Provide system controls that are UL listed for Power Limited Applications per NEC 760 (latest adopted edition), in addition to the UL-UOJZ requirement mentioned above.

- D. Provide transient protection devices on all control equipment to comply with UL864 requirements.
- E. Additional transient protection must be provided for each circuit, where fire alarm circuits leave the building. Provide devices that are UL listed under Standard 497B (Isolated Loop Circuit Protectors).
- F. Addressable devices shall be clearly labeled with their unique address in 1/4" high numerals. Labels shall be mechanically produced. Numbering hand written on the device shall not be acceptable.

1.6 SUBMITTALS

- A. Submit complete fire alarm layout drawings with equipment cut sheets and operational matrix. Depict on the layout drawings all equipment and field devices, routing of wiring, connection information, IDNet identification number for each device, etc. These drawings shall be generated in AutoCad 2004 or newer.
- B. Submittal Data: The following documents shall be submitted for review:
 - 1. Catalog Sheets.
 - 2. Plan drawings.
 - 3. Interconnect drawings.
 - 4. Wiring diagrams.
 - 5. Equipment mounting details.
 - 6. Battery Calculations.
 - 7. Operation and maintenance manuals.
 - 8. Record drawings.
- C. Documentation Requirements
 - 1. General: Prepare drawings with drafters under the supervision of engineering level personnel. Drawings shall be drawn on 24" x 36" reproducible media. Drawings shall be prepared in AutoCAD 2004 or newer.
 - 2. Catalog Sheets: Show the color, configuration, and dimensions of the equipment or device described. Provide technical specifications, such as operating voltage, operating temperature, and humidity limitations, mounting and wiring information, and a description of the function and operation of the devices.
 - 3. Layout plan drawings: Show every device provided under this section at its relative spatial location. Routing of conduit, wiring, and exact quantity of conductors shall be shown on the as-built drawings.
 - 4. Interconnect drawings; Show only external connections between equipment and devices. All wires shall be identified with alphanumeric designators and all termination points shall show the correct terminal identification.
 - 5. Wiring diagrams: Show the general physical arrangement of the component parts of the equipment and the connection of all internal wiring. All components, wires, terminal strips and terminals shall be identified with alphanumeric designators.
 - 6. Equipment mounting details: Show the mounting location for all floor and wall mounted equipment including distance from floor and column lines and fabrication

details for all special mounting brackets. Details shall also provide any special installation instructions. These details may be included on the plan drawings if the space allows.

7. Battery calculations: Calculations shall document the basis for selecting battery size. The calculations shall include an itemization of all battery loads under standby and alarm conditions.

- D. Submit Operation and Maintenance data.
- E. Submit the manufacturer's installation manual & equipment specific startup documents as a part of the initial equipment submittal.
- F. Submit the manufacturer's operating and maintenance manual as a part of the initial equipment submittal

1.7 WARRANTY

- A. Provide a warranty for the added equipment to the fire alarm system wiring and equipment to be free from inherent mechanical, electrical, and software programming defects for a period of one (1) year from the date of the completed and certified test by the Authority Having Jurisdiction.

1.8 COORDINATION DRAWINGS

- A. Each subcontractor for Division 26 and 28 is required to produce coordination drawings for the purposes of multi-disciplinary coordination.
- B. In addition to production of coordination drawings, the subcontractors shall coordinate their work and attend meetings with other subcontractors/trades, resolve conflicts, and adjust coordination drawings as required.
- C. Contractors shall provide minor adjustments and additional work necessary at no increase in Contract Sum.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURES

- A. Central Washington University presently has a Simplex fire alarm system network installed on campus. As such, the catalog numbers specified under this section are those of Simplex. Since only the Simplex fire alarm control panels are capable of communicating on the Simplex fire alarm system network, no substitutions will be allowed. Contact Jerry Dolph at (509) 993-8453.

2.2 EQUIPMENT

A. Non-Addressable Peripheral Devices

1. Fire Alarm Auxiliary Relay #2088-9008

- a. Provide a single pole, double throw relay switch for loads up to 120VAC to 10A. Coil input shall accept 24VDC/DC, 115VAC/DC, or 230VAC/DC and have internal blocking diodes to allow for operation/supervision via a style Y signal circuit. Provide power to this relay from the 24VDC power from the fire alarm control panel that controls the relay if a Relay IAM is used, or operate relay directly from a style Y signal circuit.
- b. Provide relays for interfacing the fire alarm system with the following equipment:
 - 1) Specific equipment of the air handling system
- c. Locate relays within 3 feet of equipment/circuit served by the relay. Route circuits from controlled equipment and fire alarm device (signal circuit or ZAM) into relay box. Orient relay so any 120VAC (or greater) circuit does not cross the 24VDC fire alarm circuit inside the relay box. Route ONLY 24VDC into the fire alarm device boxes. Identify breaker panel and breaker number supplying power to the relay.
- d. Electrical contractor to provide wiring from Fire Alarm auxiliary relays to the associated VFD or motor starter/controller for run inhibit.

B. ADDRESSABLE DEVICE TYPES

1. General: The system Fire Alarm Control Panel, over its two-wire multi-drop channel, must be capable of communicating with the types of addressable devices specified below in any combination up to the full point capacity of the loop.
2. Addressable Sensor Bases-#4098-9792
 - a. Provide sensor bases containing an integral LED that will flash each time the Fire Alarm Control Panel (once every 4 seconds) scans it. Turn the sensor base LED "ON" when the Fire Alarm Control Panel determines that a sensor is in the alarm or a trouble state. Sensor bases that do not provide a visible indication of an abnormal condition at the sensor location will not be acceptable.
3. TrueAlarm Smoke Sensors #4098-9714
 - a. Provide photoelectric type, addressable smoke sensors that communicate actual smoke chamber values to the system Fire Alarm Control Panel. Provide solid state, photoelectric type sensors containing no radioactive material. Use a pulsed infrared LED light source and be sealed against rear airflow entry for sensor operation.
4. Activate the supervisory function of the fire alarm detection loop upon removal of the detector head and cause a trouble signal at the Fire Alarm Control Panel. Provide a plug-in sensor unit that mounts to a twist-lock base.

5. Provide sensors with a UL #268 listing and documented as compatible with the control equipment to which they are connected. Provide sensors listed for both ceiling and wall mount applications. Provide sensors containing a magnetically actuated test switch to provide for easy alarm testing at the sensor location.
6. Scan each sensor by the Fire Alarm Control Panel for its type identification to prevent inadvertent substitution of another sensor type. Permit continued operation of the Fire Alarm Control Panel but initiate a "Wrong Device" trouble condition until the proper type is installed or the programmed sensor type is changed. The Fire Alarm Control Panel shall operate the "Wrong Device" as a default sensitivity for that type of device to provide for initiating and alarm from that device.
7. Provide sensors with electronics immune to false alarms caused by EMI and RFI.
8. Provide sensors that fit into a base that is common with both the heat detector and photoelectric type detector and non-addressable bases capable of being monitored by a Zone Adapter Module (ZAM) or Individual Addressable Module (IAM). Provide sensors compatible with other addressable manual station, and addressable Zone Adapter Modules on the same circuit.
9. Addressable Photoelectric Duct Detector-#4098-9756 (with TrueAlarm Smoke Sensor #4098-9714 internal to unit).
 - a. Provide solid state, non-polarized, 24VDC, photoelectric type duct detector compatible with the Fire Alarm Control Panel that obtains its operating power from the supervisory current in the fire alarm detection loop.
 - b. Provide duct detectors that operate on the light scattering, photoelectric principle. Provide an insect screen to minimize nuisance alarms. Provide duct detectors designed to ignore invisible particles or smoke densities that are below the factory set point. Provide duct detectors with sensor heads that are directly interchangeable with an ionization detector type. The 24VDC detectors may be reset by activating the Fire Alarm Control Panel reset switch.
 - c. Provide duct detectors with a mounting base that accepts a twist-lock type detecting head. That head shall be capable of being locked in place by a tamper resistant latch. The locking feature must be field removable when not required. Provide contacts between the base and head of the bifurcated type utilizing spring type, self-wiping contacts. Interrupt the supervisory current of the fire alarm detection loop upon removal of the detector head and cause a trouble signal at the Fire Alarm Control Panel. Provide compatibility of the detector design with other normally open fire alarm detection loop devices (heat detectors, pull stations, etc.)
 - d. Provide duct detector housings capable of being alarmed by using a test switch.
 - e. Provide duct detector housings that provide access through the front cover for cleaning the detector sampling tubes.
 - f. Employ voltage and RF suppression techniques to minimize false alarms.
 - g. Provide remote test/indicator device for all duct smoke sensors. Coordinate exact location of test switches with Owner.
10. Individual Adapter Module (IAM), Simplex #4090-9001
 - a. Use Individual Adapter Modules for monitoring water flow switches, valve tamper switches and (if called for) non-addressable detectors.

- b. Use IAMs for conventional 2-wire detection devices and/or contact devices monitored with Style Y monitoring. These IAMs will monitor and communicate the device/zone's status (normal, alarm, and trouble) to the Fire Alarm Control Panel.
- c. Uniquely identify IAMs at the Fire Alarm Control Panel. Transmit device identification to the Fire Alarm Control Panel for processing according to the program instructions. Should an IAM become non-operational, tampered with, or removed, a discrete trouble signal, unique to the device, shall be transmitted to, and annunciated at, the Fire Alarm Control Panel.
- d. Provide the capability of programming IAMs for their "address" location on the addressable device signaling line circuit. IAMs are to be compatible with addressable manual stations and addressable detectors on the same addressable circuit.
- e. Supervise the IAM for all trouble conditions. Indicate the type of trouble condition (open, short, device missing/failed) at the Fire Alarm Control Panel. Should an IAM fail, it will not hinder the operation of other system devices.

11. Zone Adapter Module (ZAM)

Monitor ZAM #4090-9101
Relay IAM #4090-9002
4-20ma AMZ #4190-9050

Provide three (3) types of devices:

Type 1: Monitor ZAM

Type 2: Relay IAM

Type 3: 4-20 ma AMZ (analog monitor ZAM)

- a. Use Type 1 ZAMs for monitoring conventional 2-wire detection devices and/or contact device monitoring with Style D monitoring. Use these types of ZAMs to monitor and communicate a zone's status (normal, alarm, and trouble) to the Fire Alarm Control Panel.
- b. Use Type 2 Relay IAMs as addressable control devices for air handler unit shut down, elevator recall, and door holder control via #2088-9008 relays. These relay IAMs will communicate with the Fire Alarm Control Panel and will receive a command to transfer the relay form the Fire Alarm Control Panel. Provide supervision of the 24 VDC riser feeding these Relay IAMs when connected to non-failsafe devices.
- c. Use Type 3 ZAMs for monitoring analog processes that provide a 4-20 ma analog current loop output.
- d. Uniquely identify devices at the Fire Alarm Control Panel. Transmit device identification to the Fire Alarm Control Panel for processing according to the program instructions. Should the ZAM become non-operational, tampered with, or removed, transmit a discrete trouble signal, unique to the device, to the Fire Alarm Control Panel.
- e. Provide the capability to program the ZAMs or IAMs for their "address" location on the addressable device signaling line circuit. Provide ZAMs compatible with addressable manual stations and addressable detectors on the same addressable circuit.

- f. Supervise the ZAM for all trouble conditions. Indicate at the Fire Alarm Control Panel the type of trouble condition (open, short, device missing/failed). Should a ZAM fail, it will not hinder the operation of the other devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring and conduit arrangement shall be supplied by vendor in shop drawings. Wire installed must be approved for "Power Limited" fire alarm use under Article 760 of the National Electrical Code.
 1. Wiring shall be installed in conduit.
 2. Splicing of conductors with wire nuts is prohibited. Where splicing is required, it shall be done on an appropriately labeled terminal strip in a NEMA enclosure.
- B. Conduit pathway system with labeled pull strings shall be provided by the Div. 26 contractor in accordance with the Simplex system vendor supplied shop drawings and these specifications. Simplex system vendor shall perform all required testing of the installed system.
- C. Additions to the wiring network shall be tested and verified with a Simplex TrueStart test meter prior to terminating any wiring within the fire alarm control panel or installing any of the smoke heads in their bases. Provide one such meter for this purpose. The meter shall become the property of CWU after testing has been completed.
- D. Upon completion of the installation and after testing and demonstration, the Simplex System Vendor shall submit to the Owner a signed statement substantially in the form as follows:
 1. The undersigned having been engaged as the Simplex System Vendor for the _____ project confirms that the fire alarm equipment was installed in accordance with the plans and specifications and in accordance with the wiring diagrams and directions provided to us by the manufacturer and that all wire installed is approved for "Power Limited Fire Alarm" use under Article 760 of the National Electrical Code.
 2. It has been completely tested and demonstrated to the Owner's representative and accepted by the Code Enforcing Authority having jurisdiction."
- E. Detectors
 1. Duct Mounted Detectors (including those at fire/smoke dampers)
 - a. Division 28 shall furnish and connect detectors which shall include connection to VFD or motor controller. Division 23 shall mount detectors.
 - b. Housing shall be located downstream of the supply fan and before the first ductwork elbow at a location recommended by the manufacturer.
 - c. Probes shall be installed in center of air stream. Probes shall extend the entire width of the ductwork.
 - d. Detector bases shall be installed in housings.

- e. Detectors shall be mounted on bases after dust and debris has been removed from ductwork.
 - f. Provide control circuit from normally closed relay contacts to fan control circuit to automatically stop fan when detector is in alarm condition (except for detectors at fire/smoke dampers – see detail on plans for operational requirements).
 - g. See Mechanical plans for quantity and location of duct detectors.
- F. Furnish and install Isolated Loop Circuit Protectors (ICLP) on all communication, IDNet II SCU/RCU and signaling lines, including shields on all circuits that extend beyond the building by any means. The ICLP shall be located as close as practicable to the point at which the circuits enter or leave a building. The ICLP grounding conductor shall be #12 AWG wire having a maximum length of 28 feet in as straight a line as practicable and connected to the building unified ground per Article 800-40 of the NEC.

3.2 TESTING

- A. The system with added/modified equipment shall be subjected to one required test. The test shall be witnessed by the owner's representative and the AHJ. This test shall be completed after the system has been on line for minimum of seven (7) days. Should the results not be satisfactory to either the CWU representative or the AHJ, then corrections will be made and a retest will be required at the Simplex System Vendor's expense. A Simplex representative and Simplex Vendor supplied fire alarm technician shall be present for all testing. The fire alarm technician shall conduct the test. Should a commissioning agent be involved with the project, and a second test is required for his benefit, it shall be included in the base price.
- B. The test shall be in accordance with a written Acceptance Test Procedure (ATP) to demonstrate and certify proper system operation. The ATP shall be prepared by the Simplex System Vendor and submitted to the Owner for approval six (6) weeks or more prior to the performance of the ATP. As a minimum provide a detailed method of testing of the following to demonstrate to the Owner that the system functions as intended by the design:

- 1. Fan control

3.3 SERVICE

- A. The system vendor must employ factory trained technicians and maintain a service organization within 200 miles of the project and be capable of responding to service calls within 24 hours.
- B. This organization must have a minimum of 5 years experience in servicing systems of the type specified above.

3.4 TRAINING

- A. The Simplex System Vendor shall, after two weeks (minimum) provide written notification to CWU to conduct a training session during which all maintenance and operational aspects of the system (including training in the use of programming software system troubleshooting)

will be described and demonstrated to personnel selected by the Owner. The sessions shall be conducted by a manufacturer's representative thoroughly familiar with the characteristics of the installed system.

- B. Required Instruction Time: Provide a total of up to one hour of instruction time during regular work hours on such date and time as are selected by CWU. All training provided for under this requirement shall be considered to take place at a single session.

3.5 OTHER ITEMS

- A. At the completion of the installation when the as-built drawings have been submitted and accepted, the Simplex System Vendor shall submit a letter to the CWU certifying that the fire alarm system is completely functional and conforms to all applicable codes, ordinances, and requirements of the contract.

3.6 PROJECT COMPLETION

- A. Project completion and payment will be based on completing of the following.
 1. Completion and approval of acceptance tests.
 2. Completion of punch list items.
 3. Delivery and acceptance of the as-built drawings and operation and maintenance manuals.
 4. Cleanup of installation site to the satisfaction of the Owner's Representative.

3.7 EQUIPMENT MANUFACTURER'S AND CONTRACTOR'S PARTICIPATION IN PROJECT COMMISSIONING

- A. Assist in developing the final functional test procedures as specified in Sections 230800, 260800 and related sections.
- B. Provide authorized startup technician to perform functional performance testing as specified in Sections 230800, 260800 and related sections.
- C. Provide building commissioning support as specified in Sections 230800, 260800 and related sections.

END OF SECTION 28 3110