A D D E N D U M N U M B E R T W O

February 10, 2023

To all contract bidders of record for the work titled:

Invitation to Bid (ITB) FM22011

D2 Materials Lab Remodel

IDAHO TRANSPORTATION DEPARTMENT

District 2
2606 Frontage Road
Lewiston, ID 83501

CKA Project Number: 22040

Please notify everyone concerned (subcontractors and suppliers) as to the issuance and contents of this Addendum prior to the date of bid opening. This Addendum is a part of the contract documents and modifies them as follows:

GENERAL

I. Bid Submission Clarification:

a. There has been a typo in the bidding documents to date in regards to the building number within the address of the ITD District 2 Headquarters. Sealed bids must be either mailed or hand delivered to the front desk at:
   i. Idaho Transportation Department – District 2, ***2600*** Frontage Road, Lewiston, ID 83501
   ii. Reference the Bid Submission Table below. Bids will be opened publicly and read aloud.

Bid Submission/Opening Table

Bid Package #	Bid Package Description	Date of Opening	Bid Submission Deadline	Time of Opening
BP-01 (FM22333)	General Construction	February 16, 2023	1:59.59 PM	2:00 PM
BP-02 (FM22334)	Plumbing	February 16, 2023	2:14.59 PM	2:15 PM
BP-03 (FM22335)	HVAC	February 16, 2023	2:29.59 PM	2:30 PM
BP-04 (FM22236)	Electrical	February 16, 2023	2:44.59 PM	2:45 PM

II. Bid Package Clarifications

a. Bid Package No. 01 – General Construction
   i. In reference to the second sentence of Note 3.b on your bid form, this package now also includes the trenching excavation, bedding, backfill, and compaction required for the new underground plumbing work. Coordinate required locations, depths, and sloping with the Plumbing Contractor.

b. Bid Package No. 02 – Plumbing
   i. In reference to Note 5 on your bid form, the General Construction Contractor will now provide the trenching excavation, bedding, backfill, and compaction required for the new underground plumbing work. Coordinate the required locations, depths, and sloping for your work.

c. Bid Package No. 03 – Electrical
   i. Provide the required slab needed for the Avista transformer. The slab for the future generator will be provided by others at a later date.

III. Substitutions:

This is an acceptance of general quality only. No attempt has been made to check each material as to special features, capacities, or physical dimensions specially required for the project. It shall be the responsibility of the supplier, manufacturer, and contractor to check all requirements before submitting for final acceptance. Final acceptance of exact features, sizes capacities, etc., all of which must match materials indicated and specified, will be determined when submitted during the construction period. Certain acceptances are subject to conditions noted.

Section / Drawing	Item	Manufacturer
Mechanical / M5.1	**Expansion Tank**	**John Wood**
Mechanical / M5.1	**Air Sediment Separator**	**Thrush**

IV. General Clarifications:

1.) Contractor to coordinate exact equipment placement and layout to accommodate existing building conditions prior to installation.

V. Prebid Questions:

1.) Question: Do you have a specification for the humidifier?
   a. Answer: Yes, see the attached updated 230100 specification. See Section 2.16.
2.) Question: Who is to provide the humidifier?
   a. Answer: The mechanical (HVAC) contractor shall provide the humidifier.
3.) Question: What type of support goes under the air handling unit (AHU-1)?
   a. Answer: The air handling unit will be installed on an isolation rail. No concrete curbs are to be used in the mezzanine.
4.) Question: Will the chiller be on a concrete pad?
   a. Answer: Chiller and condenser to be installed on concrete pads per architectural drawings.
5.) Question: Can the exhaust roof canopies be custom-fab instead of factory ordered?
   a. Answer: Exhaust canopy hoods must be factory ordered.
6.) Question: Do you have a specification for the slot hoods?
   a. Answer: Yes, see the attached updated 230100 specification. See Section 2.17.
7.) Question: What size and type of steam lines are there from the humidifier to AHU-1?

a. Answer: This is dependent upon the humidifier system. The basis of design includes 40mm input lines, and 80mm output steam lines.
b. Answer: Again, the type of material is dependent upon the humidifier system. Basis of design includes EPDM rubber steam lines.

8.) Question: What type of piping for chilled and hot water systems?
a. Answer: See specification 230100 Section 2.5 for type.

9.) Question: Where are the piping drawings for the humidifier?
a. Answer: They are located on sheet P2.1.

10.) Question: Will duct smoke detection be required on AHU-1?
a. Answer: No, there is no return air system. It is a single pass HVAC system so duct smoke detection is not required.

ARCHITECTURAL

I. DRAWINGS

A. DRAWING G1.0

1. Refer to "INDEX TO DRAWINGS" and **ADD** Sheet ***M4.6 MECHANICAL DETAILS*** (added in Addendum #2).

B. DRAWING A3.0

1. Refer to "DOOR SCHEDULE" and **ADD the following:**
   a. ***Door 111B - new 3'-0" x 7'-0" HM Door (Paint), Type "B", existing frame to remain (paint), HW-2.***
   b. ***Door 101A – paint existing door and frame to remain, HW-1.***

II. SPECIFICATIONS

A. CONTENTS (PAGE C-4)

1. Refer to "LIST OF DRAWINGS" and **ADD** Sheet ***M4.6 MECHANICAL DETAILS*** (added in Addendum #2).

B. SECTION 026000 – Existing PEMB Information

1. **CLARIFICATION:** Refer to this Section 026000 for links to the existing PEMB building.
2. **CLARIFICATION:** General Contractor to coordinate with a PEMB Vendor for all PEMB structural and roofing modifications (Deferred Design Scope). See A1.2 Roof Plan (Demo & New), M1.1 Demo Plan, M2.2 Mechanical Roof Plan, M5.0-M5.2 Equipment Schedules, and M4.0-M4.1 for Mechanical Roof Details. The Mechanical Roof Details are shown for reference to mechanical scope, coordinate with PEMB Vendor for modifications to PEMB structure and roofing.

C. SECTION 08 71 00 – Door Hardware

1. Refer to Addendum #1 which included the hardware groups.
   c. **REVISE** 4040XP to be ***LCN4040XP SCUSH closer*** for HW-7 (112A) and HW-8 (112B).
   d. Refer to HW-1 and HW-2 and **ADD** ***BB1199 4.5x4.5 32D ETW-12 electrified hinge***.

e. **REVISE:** Hardware Groups HW-2 (111B), HW-7 (112A), and HW-8 (112B) are all listed with a PS902 Power Supply. Instead of providing a power supply for each of these three doors, ***provide ONE PS902 Power Supply to power all three doors***.
CLARIFICATION: The total count for the PS902 Power Supply will therefore be only 2 (instead of 4).

f. **CLARIFICATION:** Door 101A, existing door and frame to remain. The existing frame and door will need field-drilled by the Contractor for the new electrified hinge and panic device.

g. **CLARIFICATION:** Door 111B will receive a new door, existing frame to remain. The existing frame will need field-drilled by the Contractor for the new electrified hinge.

h. **CLARIFICATION:** contractor to provide and install all door hardware. Contractor to prep existing doors/frames to receive new electrified door hardware to be compatible with door access system. ITD's Access Control Vendor (A-Tec) to provide door access system, including controller, wiring, software and related equipment and will connect to electrified door hardware when the install the access control system.

STRUCTURAL

I. DRAWINGS

A. DRAWING S1.0

1. Refer to "SHEAR WALL SCHEDULE". **ADD the following general note to the schedule: *the existing plywood installed from the floor up to 8'-0" AFF needs additional screws added to existing plywood. The existing edge nailing spacing is approximately 12" O.C. Contractor to add intermediate screws at all plywood edges to that edge nailing spacing is 6" O.C. as required for SW-2.***

PLUMBING

I. DRAWINGS

A. DRAWING M2.0 – HVAC NEW WORK FLOOR PLAN

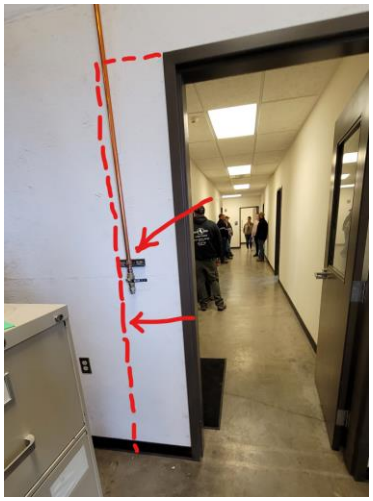
1. Change Keynote 10 to: INSTALL OUTDOOR HEAT PUMP UNIT ON 4" CONCRETE PAD WITH MIRO STAND PER DETAIL #1 ON SHEET M4.6.

B. DRAWING M4.6 – MECHANICLA DETAILS (ADDED TO PLAN SET)

1. Added Detail #1, HEAT PUMP UNIT PLATFORM DETAIL.
2. Added Detail #2, HEATING WATER SYSTEM FLUSHING & TREATMENT DETAIL.
3. Added Detail #1, COOLING WATER SYSTEM FLUSHING & TREATMENT DETAIL.

C. DRAWING P1.1 – PLUMBING DEMO PLAN

1. Refer to photo sketch below, located adjacent to Door 110B between New Performance Lab 110 and Corridor 102. Relocate existing compressed air piping and valve around new enlarged Door 110B.



ELECTRICAL

I. GENERAL

A. Exposed conduits permitted in shop spaces Performance Lab 110, Materials Storage 111, Mechanical Room 201A. The other rooms have suspended tile ceilings or new walls where conduits shall be concealed as much as practical in finished spaces. Refer to Drawing E2.2, the south wall in Asphalt Lab 106 shows new power receptacles in the existing wall. Electrical Contractor to 'fish' flex conduit down existing drywall from above new ceiling elevation 9'-0" down to receptacle locations.

II. DRAWINGS

A. DRAWING E2.3

1. Refer to Keyed Note #3 and **ADD** the following notes for the Door Access Control Power Supply routing. The Power Supply will be provided and installed by the General Contractor under "*Section 087100 Door Hardware*".
    i. **ADD:** "REFER TO DETAILS ON ***E3.0***".
    ii. **ADD: *provide conduit from power supply (087100 Door Hardware) to be centrally located and route to each doors 111B, 112A, and 112B.***
    iii. **ADD: *provide conduit from power supply (087100 Door Hardware) to be located above the suspended tile ceiling and to existing door frame 101A.***

B. DRAWING E3.1 – ELECTRICAL SCHEDULES

1. Update panel HM to make breaker at position 13,15,17 spare.
2. Update panel HA to make breakers at position 8,10 both 20A/1P spare breakers.
3. Add panel schedule for EM to the sheet

Attachments:

- Pre-Bid Conference Sign-In Sheet
- Revised Section 230100 – Heating, Ventilation, and Air Conditioning
- Added Sheet M4.6

End of Addendum Two

beniton CONSTRUCTION

District 2 – Materials Lab Remodel
Idaho Transportation Department
Meeting Attendance Sheet
Meeting Date: 02/06/2023 Meeting Time: 1:00 PM

#	Name	Company	Phone Number
1	Scott Crow	Crow Electric	(208) 791-3973
2	Tom Golis	Golis Const.	208-863-9070
3	Tim Womack	Golis Const.	208 1669 2187
4	BEN LARSEN	CLCA (ARCHITECT)	208-746-0183
5	Travis Frei	ITD	
6	Richard Tompkins	Beniton	808-633-6589
7	Al Seaman	~~Beniton~~ TWIN CITY ELECT.	208-816-0047
8	Erik Adams	K & G Const.	205-553-4409
9	Bryon Collier	Collier Electric	208-305-4147
10	Doug Engel	4J Electric	208-746-5573
11	MIKE LINDSEY	Mikes Mett	208-790-7632
12	Kaden Lyda	FSI	208-553-0599
13	Colt Dawning	Idaho Steam Const	208-615-7619
14	Kirk Free	overhead door	208-791-3651
15	Matt Boyer	overhead door	208-792-1045
16	Dave Hardin	7 Devils Painting	208-791-8658
17	Steve Wright	Wright Way Mechanical	208-790-7674
18	Kenny Oakes	KM	208-750-0496
19	Bob Dale	RD Electric	208-553-7044
20	Matt Sutherland	QV Construction	208-304-5030
21	Kevin Messicle	K&G Const	208-553-4440
22	Brian Hix	K+G CONST	208-553-2356
23	Gloria Garcia	K+G	208-790-7133
24	Chris Kilcup	K+G	208-553 4404
25	Deon Lish	K+G	208-791-7538
26	JOE BIGWETT	Valley Electric	208-743-3419
27	Tony Amundson	Early Bird Supply	208-791-4339

MA

beniton CONSTRUCTION

#	Name	Company	Phone Number
28	Jeff Carlson	Strom Electric	208-301-1704
29	Tyson Miller	ICON Const.	509-220-7998
30	MATT POLIS	STALLION SYSTEMS	509-780-7238
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SECTION 23 0100 – HEATING, VENTILATING, AND AIR CONDITIONING

PART 1 - GENERAL

1.1 SCOPE

A. This section covers the work necessary for the heating, ventilating, and air conditioning system, complete. The HVAC General Requirements, Section 23 0000, is to be included as a part of this section of the specifications.

1.2 CODES & STANDARDS

A. The heating, ventilating, and air conditioning system shall be installed in accordance with the latest edition of the following codes and standards:

1. International Mechanical Code (IMC)
2. International Building Code (IBC)
3. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
4. National Fire Protection Association (NFPA)
5. Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION

A. General:

1. All rotating equipment and appurtenances connected to rotating equipment shall be vibration isolated from the supporting structure. No metal to metal contact will be permitted between fixed and floating parts. All metal isolators exposed to weather shall be hot dipped galvanized after fabrication. Piping connected to rotating equipment shall be hung with spring hangers for first 50 pipe diameters.

B. Floor Mounted Spring Isolators:

1. Isolators shall be free standing, laterally stable, and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter to operating spring height of 1.0 and an additional travel to solid equal to 50% of rated deflection.

C. Floor Mounted Neoprene Pads:

1. Isolators shall be neoprene waffle or combination neoprene and cork sandwich. Pads shall be sized and selected as per manufacturers loading requirements.

D. Spring Hangers:

1. Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional spring travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.

2.2 SEISMIC SUPPORTS

A. All equipment, ductwork, and piping shall be seismically supported as required by the International Building Code, latest edition. Support details shall be as indicated on the Drawings.

2.3 AIR HANDLING UNIT

A. Submittals
   1. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements. Computer generated fan curves for each air handling unit shall be submitted with specific design operating point noted. A computer generated psychometric chart shall be submitted for each cooling coil with design points and final operating point clearly noted. Sound data for discharge, radiated and return positions shall be submitted by octave band for each unit. Calculations for required baserail heights to satisfy condensate trapping requirements of cooling coil shall be included.
   2. Product Data: Dimensions, weights, capacities, ratings, fan performance, finishes of materials, electrical characteristics, and connection requirements, filter media data, filter performance data, filter assembly, and filter frames, and installation instructions.

B. Delivery, Storage, And Handling
   1. Deliver, store, protect and handle products to site.
   2. Accept products on site on factory-furnished shipping skids. Inspect for damage.
   3. Store in clean dry place and protect from construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

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. The inner liner shall be constructed of G90 galvanized steel.
      b. 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.
      c. The floor plate shall be constructed as specified for the inner liner.
      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. A 6-inch formed G60 galvanized steel base rail shall be provided by the unit manufacturer for structural rigidity and condensate trapping.. The base rail shall be constructed with 12-gauge nominal for unit sizes 003 - 035 and 10gauge nominal for unit sizes 040 - 090. The following calculation shall determine the required height of the baserail to allow for adequate drainage. Use the largest pressure to determine base rail height. [(Negative)(Positive) static pressure (in)] (2) + 4" = required baserail height. Should the unit baserail not be factory supplied at this height, the contractor is required to supply a concrete housekeeping pad to make up the difference.
8. A round window inspection port shall be provided on unit section(s) as indicated on unit schedule and drawings.
9. 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. Fan Assemblies
   1. Provide ECM, motorized impeller fan(s). Fan assembly shall include fan, fan base, and a motor and shall be dynamically balanced by the fan manufacturer.
      a. Fan array shall be equipped with a piezometer point to measure airflow. One piezometer point shall be supplied on one fan in the fan array.
      b. Unit shall come equipped with an isolation backdraft damper upstream of each fan in the array. Damper shall be equipped with an adjustable, weighted counter balance to minimize static pressure loss.
      c. Motor control panel shall come with a low voltage terminal strip and shall include terminals for Fan ON/OFF, 010V signal, and fan fault.
      d. Motor control panel shall come equipped with a fused disconnect.
      e. Fan section shall come equipped with a motor control panel mounted on the fan section. Both line voltage and low voltage wiring shall be done by the factory. Each fan shall have an isolation switch.
      f. Motor shall be brushless DC type with a permanent magnet rotor.
      g. Inverter shall be integral to the motor and come as an assembly from the fan manufacturer

E. Bearings, Shafts, And Drives
   1. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

F. Electrical

1. The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to binational standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.
2. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.
3. Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.
4. Installing contractor shall provide GFI receptacle within 25 feet of unit to satisfy National Electrical Code requirements.

G. Cooling And Heating Coils
1. Certification: Acceptable water cooling, water heating, steam, and refrigerant coils shall be certified in accordance with AHRI Standard 410 and bear the AHRI label. Coils exceeding the scope of the manufacturer's certification and/or the range of AHRI's standard rating conditions will be considered provided the manufacturer is a current member of the AHRI Forced Circulation Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with AHRI Standard 410. Manufacturer must be ISO 9002 certified.
2. Water cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
    a. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
    b. Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
    c. Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins, brazed at joints.
    d. Coil connections shall be carbon steel, NPT threaded connection. Connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
    e. Coil casing shall be a formed channel frame of galvanized steel.
3. Water heating coil shall be provided. Provide access to coil(s) for service and cleaning.

Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit

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e. Coil shall be furnished as an uncased galvanized steel to allow for thermal movement and slide into a pitched track for fluid drainage.

H. Filters
1. Furnish combination filter section with 2-inch pleated MERV 8 flat pre-filter and 4-inch final filter. Provide side loading and removal of filters.
2. Filter media shall be UL 900 listed, Class I or Class II.

I. Additional Sections
1. Plenum section shall be provided and properly sized for inlet and/or discharge air flow (between 600 and 1500 feet per minute). The plenum shall provide single or multiple openings as shown on drawings and project schedule.

J. Extra Materials
1. Provide two extra sets of filters for each air handling unit.

2.4 AIR DISTRIBUTION

A. Ductwork:

1. Low pressure ductwork shall be fabricated from galvanized sheet metal, unless otherwise

indicated. Construction requirements shall be in accordance with SMACNA - HVAC Duct Construction Standards, metal and flexible, latest edition. All sheet metal ductwork shall be sealed with McGill United Sheet Duct Sealer or equal, in accordance with the International Energy Compliance Code, latest edition. Adjustable (twist) elbows are not allowed. Low pressure ductwork shall be constructed to the following SMACNA static pressure standards:

a. Supply air ductwork = 2" W.G.
b. Return, Exhaust, Outside Air Intake ductwork = 1" W.G.

2. Low pressure ductwork located exposed in exposed ceiling areas, ***shall be spiral type ducts with a "paint-grip" finish, on ductwork and associated fittings that can be painted. Joints shall be sealed evenly and in a professional manner with silver silicon. Discolored or damaged ductwork unacceptable to the Engineer shall be replaced at the Contractors expenses.***

Ductwork located in exposed ceiling areas, shall be standard galvanized sheet metal, paint-lock spiral ductwork is not acceptable. All ductwork which is to be installed in exposed ceiling areas shall be stored inside from the time of manufacturing to installation; no outside storage shall be acceptable. Sheet metal shall have a clean, uniform color. Joints shall be sealed evenly and in a professional manner with silver silicon. Discolored or damaged ductwork unacceptable to the Engineer shall be replaced at the Contractors expenses.

a. Joints: 0" to 20" diameter, interior slip coupling beaded at center, fastened to duct with screws and with sealing compound applied continuously around joint before assembling and after fastening. Sealing compound shall be applied in an evenly and professional manner.
b. Joints 22" – 72" diameter, use 3-piece, gasketed, flanged joints consisting of 2 internal flanges (with integral mastic sealant) split to accommodate minor differences in duct diameter, and one external closure band designed to compress gasketing between internal flanges. Manufacturer shall be Ductmate Spiralmate or equal.
c. All takeoff or branch entrances shall be by means of factory-fabricated fittings. Field taps shall not be allowed.

3. Low pressure ductwork which is exposed or located in mechanical rooms shall be fabricated from galvanized sheet metal. Construction requirements shall be in accordance with SMACNA HVAC Duct Construction Standards, metal and flexible, latest edition.

4. Medium pressure ductwork shall be single wall, galvanized steel, spiral or oval duct as shown on the drawings. Ductwork shall be McGill Uni-Seal, Metaltec, or equal. Medium pressure ductwork shall be constructed to the following SMACNA static pressure standards:
   a. Supply air ductwork from air handler to the terminal unit = 4" W.G.

   All medium pressure ductwork shall be leak tested. Duct leakage test criteria shall be limited as follows:
   a. All supply ductwork from air handler to terminal unit: 1% of design cfm at 4" of static pressure.
   b. Duct leakage testing:

1) Perform testing in accordance with the HVAC Air Duct Leakage Test Manual and SMACNA.
2) Use a certified orifice tube for measuring the leakage.
3) Define section of system to be tested and blank off.
4) Determine the percentage of the system being tested.
5) Using that percentage, determine the allowable leakage 9 (cfm) for that section being tested.
6) Pressurize to operating pressure and repair any significant or audible leaks.
7) Re-pressurize and measure leakage.
8) Repeat steps 6 and 7 until leakage measured is less than the allowable in step 5.

5. Low or medium pressure, double wall acoustically insulated ductwork shall have a minimum 1" insulation, & perforated metal lining, & shall be McGill Acousti-k27, Metaltec, or equal.

6. Fume hood exhaust ducts:
   a. Fume hood and lab exhaust ductwork shall be single wall 316L stainless steel (where required), ASTM-A312 built for structural strength. Otherwise fume hood and lab exhaust ductwork shall be medium pressure galvanized steel. See plans for locations and requirements. Protect finish with mill applied protective plastic/paper throughout construction. All balancing dampers and other accessories located in the fume hood exhaust duct system shall be 316 stainless steel (where required), and galvanized steel otherwise.
      1) All lab exhaust ductwork except the individual runouts from the main to the fume exhaust hood.
         a) Duct shall be a minimum of 18 gauge.
         b) Elbows and angles shall have the same gauge as ductwork, inside radius not less than width of ductwork.
         c) The duct system shall be fitted with copper grounding straps, connected to the duct and to an effective grounding system.
         d) Provide drains at low points in ductwork.
         e) See fabrication requirements below for ductwork fabrication and assembly requirements.
         f) Note that all fittings, accessories, etc. in the fume hood and laboratory exhaust ductwork system shall be fabricated from 316 stainless steel (where required) otherwise galvanized steel.
      2) All lab exhaust runouts from the main to fume exhaust hoods.
         a) Duct shall be a minimum of 18 gauge.
         b) Elbows and angles shall have the same gauge as ductwork, inside radius not less than width of ductwork.
         c) The duct system shall be fitted with copper grounding straps, connected to the duct and to an effective grounding system.
         d) Ducts shall be sloped back to their respective hood.
         e) Longitudinal and transverse joints between ductwork and fittings shall be continuous purge welded with Argon gas. Use of spot welds and sealants is prohibited.

f) Note that all fittings, accessories, etc. in the fume hood and laboratory exhaust ductwork system shall be fabricated from 316 stainless steel (where required) otherwise galvanized steel.

7. Ductwork penetrating protective elements of fire-rated corridor walls, with no openings into corridor, shall be constructed of minimum 26 gauge galvanized steel.

8. Exterior exposed ductwork shall be fabricated from galvanized sheets. All joints and seams shall be standing-seam type with sealing mastic to provide watertight construction. All ductwork shall be internally insulated as hereinafter specified. All exposed surfaces shall be primed and painted two coats of exterior enamel paint, color as selected by the Architect.

9. Flexible ducts shall be listed per UL-181 standard as Class 1 flexible, acoustical insulated air duct and complying with NFPA Standards 90A and 90B. Ducts shall be insulated with a minimum R-6 value, and shall have a maximum vapor transmission value of .05 perms. Ducts shall be factory made with and composed of: a PE liner duct permanently bonded to a coated spring steel wire helix. Duct shall be chlorine free and carry a ten-year warranty for the labor to replace the duct should there be a factory defect. Low permeability outer vapor barrier of fiberglass bidirectional reinforced metalized laminate shall complete the composite. Pressure rating shall be 6" w.g. and maximum length shall be 6 feet. Attach to duct take-off, diffuser, register, or grille only, with nylon or stainless steel duct clamp or tie. Flexmaster 1-M, or approved equal.

B. Duct Accessories:

1. Turning vanes shall be installed in all rectangular or square elbows. Vanes shall be installed in vane side rails. Vanes shall be single wall vanes, and be fabricated and installed per SMACNA standards.

2. Volume dampers shall be fabricated from galvanized steel in accordance with SMACNA standards. Dampers shall have a continuous galvanized steel shaft on ducts 13” diameter or larger, with damper regulators and end bearings. Dampers located above inaccessible ceilings (hard ceilings) shall be furnished with concealed ceiling damper regulators. Dampers shall be pressure rated equal to the design duct pressure rating. Dampers shall be provided at all diffuser and supply/exhaust grille takeoffs, regardless if indicated on the plans. Dampers are not required on the return air takeoffs unless specifically indicated.

3. Flexible connections shall be provided at all rotating fan equipment. Connectors shall be of fire, water, and weather resistant material.

4. Fire dampers shall be UL-labeled with frame, locking assembly, accordion style folded blades, and fusible link. Dampers shall be Style B with blades stored outside of the air stream. Provide duct inspection door at each fire damper. Minimum size shall be 8" x 8". Inspection door shall be provided with a steel frame with gasketing around periphery, and a hinged panel. Dampers located in moisture laden air conditions shall have all metal parts made of

stainless steel.

5. Combination smoke and fire dampers are to be fusible link type with factory sleeve and electric operator located exterior to duct 120 V. operator to be spring return, fail closed with 212 degrees F link and UL label. Provide duct inspection door at each damper. Minimum size shall be 8" x 8". Inspection door shall be provided with a steel frame with gasketing around periphery, and a hinged panel. Dampers located in moisture laden air conditions shall have all metal parts made of stainless steel. Belimo operators/actuators only.

6. Smoke dampers are to be ultra-low leakage (less than 4CFM/ft^2) type with factory sleeve and electric operator located exterior to duct 120 V. operator to be spring return, fail closed and UL label. Provide duct inspection door at each damper. Minimum size shall be 8" x 8". Inspection door shall be provided with a steel frame with gasketing around periphery, and a hinged panel. Dampers located in moisture laden air conditions shall have all metal parts made of stainless steel. Belimo operators/actuators only.

7. A plastic flex elbow support by Flexible Technologies Inc., Titus FlexRight, or approved equal, is required at all flex duct elbows supplying ceiling diffusers & return grilles. Elbow support shall be fully adjustable, or be of universal design, to support flexible diameters 6" – 16", sized to fit flex duct. Elbow supports shall be UL rated for use in return air plenum spaces. At the Contractor's option, a hard elbow may be used in lieu of a flexible elbow.

C. Diffusers, Registers, Louvers, Grilles, Weathercaps:

1. See Drawings for requirement.

D. Duct Cleanliness:

1. Ductwork Delivery To Site
   a. During ductwork being delivered from the premises of the manufacturer, care must be taken to prevent damage during transportation and off-loading.

2. Temporary Storage
   a. Job site duct material storage areas should be clean, dry, and located away from high dust generating processes such as masonry or tile cutters, cutoff saws, drywall sanding, mortar and plaster mixers, roof pitch kettles, portable electric generators, and main walkways that will be constantly broom swept. The general contractor should designate a suitable area for temporary storage.
   b. To prevent ductwork material damage from standing water, storage locations should include pallets or blocking to keep fabricated metal ductwork above the floor surface. If there is a risk of water runoff from above or dusty areas cannot be avoided, coverage should be used to protect stored materials.

3. Installation
   a. Before the installation of individual duct sections, they are to be inspected to ensure

that they are free from all debris.

b. All ductwork risers must be covered to prevent the entry of debris into the duct.
c. Downward facing and horizontal ductwork openings will not be required to be covered.
d. Access covers shall be firmly fitted in position on completion of each section of the work. Open ends on completed ductwork and overnight work-in-progress shall be sealed.
e. The working area should be clean and dry and protected from the elements.
f. The internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation.

4. Advanced Cleanliness- For Hospitals, Laboratories, & Cleanrooms
   a. In addition to the provisions previously described, the following requirements should also be undertaken:
      1) All self-adhesive labels for part identification are to be applied to external surfaces only.
      2) To maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.
      3) All sealed ends shall be visually examined and if damaged resealed with an appropriate material.
      4) The working area shall be clean, dry and the ductwork protected from dust. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

2.5 PIPING SYSTEMS

A. Chilled Water Piping and Fittings:

1. Piping shall be standard weight (schedule 40), ASTM A53 black steel pipe with 125 pound black, screwed or welded, malleable iron fittings.

2. At the contractor's option Victaulic, Shurjoint, or Anvil Gruvlock grooved, schedule 40, black steel piping in accordance with A-53B/A-106B with roll grooved ends may be used in lieu of welded systems. Grooved products must conform to ASTM A536, Grade 65-45-12ductile iron. Carbon Steel, A-538/A-1068 – Roll or cut grooved-ends as appropriate to pipe material, wall thickness, pressures, size and method of joining. Pipe ends to be grooved in accordance with the current listed standards conforming to ANSI/AWWA C-606.

3. Grooved Mechanical Couplings

   Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183,

minimum tensile strength 110,000 psi.

a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.
   1) 2" through 12": Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C) without the need for high temperature lubricants. Basis of design: Victaulic Style 107.

b. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used inlieu of flexible connectors at pump connections. Three couplins for each connector shall be placed in close proximity to the vibration source. Please note this applies only to pumps and not other pieces of equipment.
   1) 2" through 8": Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C) without the need for high temperature lubricants.
   2) 10" through 12": Standard flexible couplings. Gasket shall be Grade "E" EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C). Basis of design: Victaulic Style 77.

4. At the contractor's option, piping may be Type L hard drawn copper, ASTM B88. Fittings shall be cast brass, ANSI/ASME B16.23, or solder wrought copper, ANSI/ASME B16.29. Joints shall be ASTM B32 solder, grade 95TA.

5. At the contractor's option copper tube may be installed with grooved mechanical joints in lieu of soldering. 2"-8" for copper tubing consisting of ductile iron cast housings, complete with a synthetic rubber gasket of a pressure-responsive design, with plated nuts and bolts to secure unit together. Couplings shall be manufactured to connect copper tubing sized tube and fittings. (Flaring of tube and fitting ends to IPS dimensions is not allowed.)
   a. Coupling Housings: Ductile iron conforming to ASTM A-536, Grade 65-45-12, coated with copper colored alkyd enamel. Housings cast with offsetting, angle-pattern bolt pads to provide rigidity.
   b. Coupling Gaskets: Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg. F to +250 deg. F.
   c. Basis of design: Victaulic Style 607.

6. Piping underground or below slab shall be Schedule 80 PVC, ASTM D1785 or D2241. Fittings shall be PVC, ANSI/ASTM D2466. Joints shall be solvent weld, ASTM D2855, or gasketed, ASTM F477. Piping shall be rated for not less than 150 psig pressure.

B. Hot Water Heating Piping and Fittings:

1. Piping shall be standard weight (schedule 40), ASTM A53 black steel pipe with 125 pound

black, screwed or welded, malleable iron fittings.

2. At the contractor's option, piping may be Type L hard drawn copper, ASTM B88. Fittings shall be cast brass, ANSI/ASME 816.23, or solder wrought copper, ANSI/ASME 816.29. Joints shall be ASTM 832 solder, grade 95TA.

C. Refrigerant Piping:

1. Refrigerant piping shall be manufacturer's standard line sets, in lengths as required for proper installation. Coiling of excess tubing will not be acceptable.

2. Provide factory wall outlet Airex Titan Outlet by Airex Manufacturing Inc. or equal. Wall outlet shall be provided with compression gasket and seal and fastened with non-corrosive screws with pre-loaded neoprene washers. Wall outlet shall be provided with an integrated over-molded flexible elastomeric sleeve for sealing, isolating and supporting refrigerant pipes from vibration. The wall outlet must provide for expansion and contraction wall protection features with gaskets and seals. A stainless-steel clamp must be provided and installed to provide a watertight seal.

D. Condensate Drain Piping:

1. Exterior to building, or located in plenum: Piping shall be Type L hard drawn copper, ASTM B88 with solder joints. Copper piping shall not be used on 90% condensing type equipment.

2. Interior: Piping shall by Type L hard drawn copper, ASTM B88, with solder joints, grade 95TA, or shall be Schedule 40 PVC. Copper piping shall not be used on 90% condensing type equipment.

E. Pipe Hangers and Supports:

1. See Section 220100 for hanger and support requirements for piping systems. See drawings for seismic support requirements for piping systems.

F. Piping Accessories:

1. Piping Hydronic Thermometer: Thermometer shall be 3" bimetal dial thermometers with recalibrator with a 0°F to 250°F range and 2°F scale and accurate within 1% of scale range. Thermometer shall be provided with an Vari-angle Form angle stem and thermowell. Thermometers shall be installed in the hydronic system in a neat workman like manner, aligned vertically and horizontally with other thermometers in the system. The thermometers shall be installed no higher than 9'-0" above finish floor and be readable from finish floor. Weiss instrument or approved equal.

2. Piping Hydronic Pressure Gauges: Pressure gauges shall be 4½" diameter, liquid filled gauges with ranges to meet 1.5 times the pressure ratings of the system its serving.

Pressure gauges shall be provided with quarter turn ball valve isolation valves on the source side and on the bleed off line. Pressure gauges shall be installed in the hydronic system in a neat workman like manner, aligned vertically and horizontally with other pressure gauges in the system. The pressure sensors shall be installed no higher than 9'-0" above finish floor and be readable from finish floor. Weiss instrument or approved equal.

3. Air Vent: Non-modulating, high capacity, automatic type designed to purge free air from the system and provide positive shutoff at pressures up to 150 psig at a maximum temperature of 250°F. Vent shall be constructed of cast iron body and bonnet with stainless steel, brass, EPDM, and silicon rubber internal components.

J. Valves:

1. See Section 220100 for valve requirements.

K. Grooved Piping Requirements:

1. Grooved Pipe Valves:
   a. Butterfly Valves – 2" through 12" Sizes: 300 psi CWP suitable for bidirectional and dead-end service at full rated pressure. Body shall be grooved end black enamel coated ductile iron conforming to ASTM A536. Disc shall be electroless nickel plated ductile iron with blowout proof 416 stainless steel stem. Disc shall be offset from the stem centerline to allow full 360 degree circumferential seating. Seat shall be pressure responsive EPDM. Basis of design: Victaulic Vic®-300 MasterSeal™ or approved equal.
   b. Check Valves – 2" through 3" Sizes Spring Assisted: Black enamel coated ductile iron body, ASTM A-536, Grade 65-45-12, stainless steel non-slam tilting disc, stainless steel spring and brass shaft, nickel-plated seat surface, 365 psi. Victaulic Series 716H / 779 or approved equal.
   c. General Duty Valves – Tri-Service Valve Assembly: Combination shut-off, throttling and non-slam check valve.
      1) 2-1/2" through 12" Sizes: Butterfly valve with memory stop feature assembled with spring assisted, non-slam check valve. Check valve may include venture-like taps for flow measurement. Working pressures to 300 psi. Basis of design: Victaulic Series 761 butterfly valve in combination with Victaulic series 716 or 779 Check valve or approved equal.

2. Grooved Pipe Specialties:
   a. Strainers – Grooved-End
      1) T-Type Strainer: 2" through 12" sizes, 300 PSI T-Type Strainer shall consist of ductile iron (ASTM A-536, Grade 65-14-12) body, Type 304 stainless steel frame and mesh removable basket with No. 12 mesh, 2"-3" strainer sizes, or No. 6 mesh, 4"-12" strainer sizes, 57% free open area. Basis of design: Victaulic Style 730 / W730 or approved equal.
      2) Y-Type Strainer, 2" through 18" sizes, 300 PSI, Y-Type Strainer shall consist of ductile iron body, ASTM A-536, Grade 65-45-12, Type 304 stainless steel

perforated metal removable baskets with 1/16" (1,6mm) diameter perforations 2"-3" strainer sizes, 1/8" (3.2mm) diameter perforations 4"-12" strainer sizes, and 0.156" (4mm) diameter perforations 14"-18" basis of design strainer sizes. Basis of design: Victaulic Style 732 / W732 or approved equal.

b. Suction Diffuser – Flanged outlet with grooved inlet connections, rated to 300 psi. Ductile iron (ASTM A-536) body, 304 stainless steel frame and perforated sheet diffuser with 5/32" (4,0mm) diameter holes. Removable 20 mesh 304 stainless steel start-up pre-filter, outlets for pressure/temperature drain connections, and base support boss. Basis of design: Victaulic Series 731-G and W731-G or approved equal.

3. Quality Assurance
   a. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by one manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

4. Execution:
   a. Installation:
      1) Pipe ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing.
      2) The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
      3) Couplings installation shall be complete when visual metal-to-metal contact is reached.
   b. Training:
      1) A factory trained representative (direct employee) of the grooved product manufacturing company shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.
   c. Application:
      1) A representative of the grooved system supplier shall periodically visit the job site and review installation. Contractor shall fix and/or replace any improperly installed products.
      2) Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods.
      3) All grooved components shall conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-31.9, ASME, UL/ULC, FM, IAPMO or BOCA.
      4) Grooved end product manufacturer to be ISO-9001 certified.

2.6 HEATING WATER PIPING CLEANING & CHEMICAL TREATMENT

A. The Mechanical Contractor shall fill each heating piping system with clean fresh water prior to cleaning and thoroughly leak check system piping. A qualified water treatment contractor shall be utilized to furnish the cleaning material and supervise the flushing and treatment of the system.

Approved water treatment contractors must show proof of similar service for not less than 3 years, and shall have full-time service personnel located within one hour from the job site. A cleaning and passivating agent supplied by the Chemical Treatment Contractor shall be added to the system at the direction of the Treatment Contractor during the leak check process to minimize initial corrosion. If the system is filled multiple times during the leak check and repair process the Mechanical Contractor shall coordinate with the Treatment Contractor to maintain this initial protection. The Treatment Contractor is responsible for providing chemical for up to two refills of the system. If additional chemical is required due to multiple re-fillings the Mechanical Contractor shall be responsible for the additional time and chemical.

B. The Mechanical Contractor shall close isolation valves at each hot water coil and open the bypass valve to prevent flow through the strainer, flow control device and coil during the initial flushing and subsequent cleaning. The side stream filter bag shall be removed during the initial flushing process.

C. Following leak check the closed system shall be flushed by the Mechanical Contractor until the leaving water runs clear. All primary runs shall be flushed at their ends to obtain maximum sweep of cutting oils and debris from the system. The inlet screens on the circulating pumps must be kept clear during this initial cleaning process and inspected following cleaning. When flushing is complete the system is to be left full. The water treatment contractor shall insure that the system not be left dry during system drain-down.

D. Prior to flushing the Mechanical Contractor shall coordinate with Treatment Contractor so that the Treatment Contractor can be available immediately following flush to add cleaning chemical within 4 hours to prevent initial corrosion.

E. Following initial flushing the Chemical Treatment Contractor shall refill all systems with cleaning and passivating agents raising the PH to a minimum of 10, circulate and flush until thoroughly clean. All primary piping runs shall be flushed at the ends during this cleaning process. The side stream filter bags shall be inspected during cleaning and changed as required. Cleaning shall continue until these bags no longer show signs of debris.

F. Heat solution to 180° F and circulate for a minimum of 8 hours, then flush system with clean fresh water until all solids have been cleaned from the system. Clean all strainers in system.

G. Following cleaning process the Treatment Contractor shall close the bypass valves at each hot water coil and open isolation valves for normal operation and check for leaks. The bypass valve handle shall be removed and tied to the valve. A clean bag filter shall be installed in the system.
   a. The water treatment contractor shall refill system with a mixture of 70% volume of softened clean water and 30% volume of dowfrost HD propylene glycol with built-in chemical inhibitor.

H. The Treatment Contractor shall provide final inspection report for inclusion in the Operation and Maintenance Manual. Additionally, the Treatment Contractor shall take loop samples approximately 12 months following completion, add or adjust chemical as required and provide

a post construction report to the owner prior to warranty closeout. Chemical required is the responsibility of the Treatment Contractor.

2.7 CHILLED WATER PIPING CLEANING & CHEMICAL TREATMENT

A. The Mechanical Contractor shall fill each chilled water piping system with clean fresh water prior to cleaning and thoroughly leak check system piping. A qualified water treatment contractor shall be utilized to furnish the cleaning material and supervise the flushing and treatment of the system. Approved water treatment contractors must show proof of similar service for not less than 3 years, and shall have full-time service personnel located within one hour from the job site. A cleaning and passivating agent supplied by the Chemical Treatment Contractor shall be added to the system at the direction of the Treatment Contractor during the leak check process to minimize initial corrosion. If the system is filled multiple times during the leak check and repair process the Mechanical Contractor shall coordinate with the Treatment Contractor to maintain this initial protection. The Treatment Contractor is responsible for providing chemical for up to two refills of the system. If additional chemical is required due to multiple re-fillings the Mechanical Contractor shall be responsible for the additional time and chemical.

B. The Mechanical Contractor shall close isolation valves at each chilled water coil and open the bypass valve to prevent flow through the strainer, flow control device and coil during the initial flushing and subsequent cleaning. The side stream filter bag shall be removed during the initial flushing process.

C. Following leak check the closed system shall be flushed by the Mechanical Contractor until the leaving water runs clear. All primary runs shall be flushed at their ends to obtain maximum sweep of cutting oils and debris from the system. The inlet screens on the circulating pumps must be kept clear during this initial cleaning process and inspected following cleaning. When flushing is complete the system is to be left full. The water treatment contractor shall insure that the system not be left dry during system drain-down.

D. Prior to flushing the Mechanical Contractor shall coordinate with Treatment Contractor so that the Treatment Contractor can be available immediately following flush to add cleaning chemical within 4 hours to prevent initial corrosion.

E. Following initial flushing the Chemical Treatment Contractor shall refill all systems with cleaning and passivating agents raising the PH to a minimum of 10, circulate and flush until thoroughly clean. All primary piping runs shall be flushed at the ends during this cleaning process. The side stream filter bags shall be inspected during cleaning and changed as required. Cleaning shall continue until these bags no longer show signs of debris.

F. Following cleaning process the Treatment Contractor shall close the bypass valves at each chilled water coil and open isolation valves for normal operation and check for leaks. The bypass valve handle shall be removed and tied to the valve. A clean bag filter shall be installed in the system.

a. The water treatment contractor shall refill system with a mixture of 70% volume of softened clean water and 30% volume of dowfrost HD propylene glycol with built-in chemical inhibitor.

G. The Treatment Contractor shall provide final inspection report for inclusion in the Operation and Maintenance Manual. Additionally, the Treatment Contractor shall take loop samples approximately 12 months following completion, add or adjust chemical as required and provide a post construction report to the owner prior to warranty closeout. Chemical required is the responsibility of the Treatment Contractor.

2.8 INSULATION

A. General:

1. All insulation shall have composite fire and smoke hazard ratings, as tested by ASTM E-84, NFPA 255, and UL 723, not exceeding:

Flame Spread	25
Smoke Developed	50

B. Ductwork - External Insulation:

1. Insulation shall be fiberglass insulation with aluminum foil scrim kraft facing. All joints shall be taped with UL listed tape to provide a continuous vapor barrier. The following ducts shall be externally insulated:
   a. Supply ducts in unconditioned spaces (unless internally insulated)
   b. Return ducts in unconditioned spaces (unless internally insulated)
   c. Combustion air ducts
   d. Outside air intake ducts
   e. Exposed ductwork located within conditioned spaces shall not be externally insulated

2. Insulation thickness & "R" values shall be as follows:
   a. R-6 – ducts located in unconditioned spaces (such as above ceiling, but below roof insulation) and outside air intake ducts.
   b. R-12 – ducts located outside of the building's insulation envelope (such as above the attic insulation).

C. Ductwork - Internal Insulation:

1. Insulation shall be flexible fiberglass duct liner. Liner shall be attached with 100% coverage of manufacturers recommended adhesive and welded or mechanically fastened galvanized steel pins. All exposed edges of liner shall be coated with adhesive. Duct dimensions shown are net air side face-to-face of duct liner. The following ducts shall be internally insulated:
   a. Supply and Return ducts within 15'-0" of air handler

b. Supply and Return ducts in mechanical rooms
c. 15'-0" downstream of VAV terminal units.
d. 15'-0" downstream of fan coil units.
e. Exterior ducts (located outdoors)
f. Buried ductwork below concrete slab
g. Ducts as indicated on plans

2. Insulation thickness & "R" values shall be as follows:
   a. R-6 – ducts located in unconditioned spaces (such as above ceiling, but below roof insulation, or buried ductwork) and outside air ducts located outside of the building envelope.
   b. R-12 – ducts located outside of the building's insulation envelope (such as above the roof).

D. Piping Insulation - Chilled Water, Heating Water, Steam, and Condensate Return:

1. Insulation shall be preformed fiberglass insulation with a vapor barrier jacket. Insulation shall have a conductivity not exceeding 0.27 Btu-inch/hour-sq. ft.-°F. Lap and butt joints shall be sealed with pressure sensitive joint sealing tape of the same finish as the insulation jacket to provide a continuous vapor seal. Fittings and valves shall be insulated with PVC fitting covers and fiberglass insulation inserts, or with hydraulic setting insulating cement and four ounce canvass jacket with vapor barrier adhesive. Insulation thickness shall be as follows:

	Nominal Pipe Diameter		
Fluid	½"to < 1½"	1 ½" to < 4"	4" and above
Heating Water	1 ½"	2"	2"
Chilled Water	½"	1"	1"

E. Piping Insulation - Refrigerant Piping:

1. Insulation on refrigerant suction piping shall be one-piece preformed flexible formed tubing with built-in closed cell vapor barrier. Seal laps and butt joints with moisture resistant adhesive to provide a continuous vapor seal. Cover all insulated suction lines exposed on the exterior of the building with E-Flex Guard by Airex Manufacturing, Inc. At exterior wall penetration provide Titan outlet by Airex Manufacturing, Inc. or equal with an Insulation thickness as follows:

	Nominal Pipe Diameter		
Refrigerant line set type	1" and less	1" to < 1½"	1 ½" and above
Located with-in the conditioned spaces			
Suction	½"	1"	1"
Liquid	not required		
Discharge (hi/low pressure)	1"	1"	1"

Located outside the conditioned spaces			
Suction	½"	1"	1"
Liquid	not required		
Discharge (hi/low pressure)	1 ½"	1 ½"	2"

F. Piping Insulation - Exterior (Outdoor) Piping:

1. Piping located outdoors shall be insulated as specified above. In-addition piping shall be covered with a weather-proof aluminum alloy 3003 or 3105 jacket meeting ASTM standard B209, minimum 0.016" think, installed per the manufacturer's installation requirements. At a minimum the following installation shall occur. The jacketing overlap shall be a minimum of 2". Horizontal piping shall have the jacket seams located at the 3 o'clock or 9 o'clock position with the seam joint openings point downward to shed moisture. Vertical piping shall have the upper jacket seams overlap the lower seam to shed moisture. Valve handles and gauges shall be positioned on the bottom to help prevent water penetration. Banding shall be used to secure the jacketing; screws, rivets, and all other fasteners capable of penetrating the underlying vapor retarder shall be prohibited. Jacketing sealant shall be applied to all longitudinal and circumferential joints and the sealant shall be located between the aluminum jacket, not at the outer lip.

G. Equipment Insulation:

1. Equipment shall be insulated with 2" thick fiberglass, minimum 6 pounds/cubic foot density. Insulation shall be finished with hydraulic setting insulating cement (1/2" thick), 6 ounce canvas, and one layer of Arabol over entire surface. Equipment to be insulated includes the following:
   a. Hot water expansion tank
   b. Air separator
   c. Chilled water buffer tank

2.9 HEAT GENERATION

A. Condensing High Efficiency Boilers

1. General:
   a. Quality Assurance
      1) Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.
         a) The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
         b) Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
      2) ASME Compliance: Boilers shall bear ASME "H" stamp and be National-Board listed.

3) FM Compliance: Control devices and control sequences according to requirements of FM.
4) Comply with NFPA 70 for electrical components and installation.
5) IRI Compliance: Control devices and control sequences according to requirements of IRI (GE GAP).
6) CSD-1.
7) SCAQMD Rule 1146.1 & 1146.2 for low NOx equipment.

2. Warranty:
   a. General Warranty: The special warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents. Installing contractor shall provide one year of warranty parts and labor.
   b. Special Warranty: Submit a written warranty, executed by the contractor for the heat exchanger.
      1) Warranty Period: Manufacturer's standard, but not less than 10 years from date of Substantial Completion on the heat exchanger. Warranty shall be non-prorated and not limited to thermal shock. Additional 21 year thermal shock warranty on heat exchanger.
         Standard Warranty is pro-rated after 5 years for commercial products.
      2) All other components shall carry a one year warranty from date of boiler start up.

3. Manufacturers:
   a. Available Manufacturers: Manufacturer shall be a company specializing in manufacturing the products specified in this section with minimum five (5) years' experience. Subject to compliance with requirements, manufacturers offering boilers that may be incorporated into the Work include, but are not limited to, the following:
   b. Design: Boilers shall be CSA design certified as a condensing boiler. Boilers shall be designed for a minimum of 5:1 continuous turn down with constant CO2 over the turndown range. The boiler shall operate with natural or propane gas and have a CSA International certified input rating as noted on the drawings, and a thermal efficiency rating up to 99% at minimum input. The boiler shall be symmetrically air-fuel coupled such that changes in combustion air flow or flue flows affect the BTUH input without affecting combustion quality. The boiler will automatically adjust input for altitude and temperature induced changes in air density. The boiler will use a proven pilot interrupted spark ignition system. The boiler shall use a UL approved flame safeguard ignition control system using UV detection flame sensing. The UV detector shall be air cooled to prevent condensate formation and so designed as to prevent misalignment. The design shall provide for silent burner ignition and operation. The boiler shall be down fired counter flow such that formed condensate always moves toward a cooler zone to prevent re-evaporation. An aluminum corrosion resistant condensate drain designed to prevent pooling and accessible condensate trap shall be provided. A means of neutralizing the condensate Ph levels shall be required. Boiler shall be able to vent a horizontal distance of 80 equivalent

feet with a vent diameter equivalent to the combustion chamber outlet diameter.

c. Service Access: The boilers shall be provided with access covers for easily accessing all serviceable components. The boilers shall not be manufactured with large enclosures, which are difficult to remove and reinstall. All accesses must seal completely as not to disrupt the sealed combustion process. All components must be accessible and able to adjust with the removal of a single cover or cabinet component.

d. Indicating lights: Each boiler shall include a diagnostic control panel with a full text display indicating the condition of all interlocks and the BTUH input percentage. Access to the controls shall be through a completely removable cover leaving diagnostic panel intact and not disrupted.

4. Components

a. General: Boiler shall be natural gas fired, fully condensing, and fire tube design. The boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

b. Heat Exchanger: The heater exchanger shall bear the ASME “H” stamp for 160 psi working pressure and shall be National Board listed. The heat exchanger shall be constructed of a fully welded stainless steel and of fire tube design. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.

c. Efficiency: Boilers shall have an AHRI certified minimum thermal efficiency of 97 percent.

d. Condensate Collection Basin: Fully welded stainless steel and shall include a stainless steel combustion analyzer test port.

e. Pressure Vessel: The pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The pressure vessel shall be designed for a single-pass water flow to limit the water side pressure drop. The pressure vessel shall contain a volume of water no less than 19 gallons.

f. Burner: Natural gas, forced draft single burner premix design. The burner shall be high temperature stainless steel with a woven Fecralloy outer covering to provide modulating firing rates. The burner shall be capable of the stated gas train turndown without loss of combustion efficiency.

g. Blower: Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.

h. Gas Train: The boiler shall be supplied with a negative pressure regulation gas train and shall be capable of minimum turndown of 10:1.

i. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

j. High Altitude: Boiler shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments. High altitude operation shall be certified at

a minimum of 4,500 feet above sea level by a third party organization. High altitude boilers shall be certified to 3,000 to 12,000 feet above sea level. The boilers shall carry a CSA certification for high altitude operation up to 12,000 feet.

k. Casing:
   1) Jacket: Heavy gauge primed and painted steel jacket with snap-in closures.
   2) Control Compartment Enclosures: NEMA 250, Type 1A.
   3) Insulation: Minimum ½ inch thick, mineral fiber insulation surrounding the heat exchanger.
   4) Combustion-Air Connections: Inlet and vent duct collars.

l. Characteristics and Capacities:
   1) Heating Medium: Hot water with propylene glycol.
   2) Design Water Pressure Rating: 160 psi working pressure.
   3) Safety Relief Valve Setting: 50 psig.
   4) Minimum flow rate of 30-gpm.

m. Trim:
   1) Safety relief valve.
   2) Pressure Gage: Minimum 3-1/2 inch diameter. Gage shall have normal operating pressure about 50 percent of full range.
   3) Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.
   4) Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.
   5) Modulation Control
   6) Blocked flue detection switch
   7) Low gas pressure safety switch
   8) Low water cutoff with amnual reset
   9) Air inlet filter
   10) Supply outlet digital display
   11) High gas pressure switch and valve providing switch for IRI compliant gas train.

5. Controls:
   a. Boiler controls shall feature a standard, factory installed multi-color graphic LCD screen display with navigation dial and includes the following standard features:
      1) Con-X-Us capable: Boiler shall have the ability to communicate remotely using the optional Con-X-Us software via a wireless or Ethernet connection.
      2) Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.
      3) Outdoor air reset: Boiler shall calculate the set point using a field installed, factory supplied outdoor sensor and an adjustable reset curve.
      4) Pump exercise: Boiler shall energize any pump it controls for an adjustable time if the associated pump has been off for a time period of 24 hours.
      5) Ramp delay: Boiler may be programmed to limit the firing rate based on six

limits steps and six time intervals.

6) Boost function: Boiler may be programmed to automatically increase the set point a fixed number of degrees (adjustable by installer) if the setpoint has been continuously active for a set period of time (time adjustable by installer). This process will continue until the space heating demand ends.
7) Time clock: Boiler shall have an internal time clock with the ability to time and date stamp lock-out codes and maintain records of runtime.
8) Maintenance reminder: Boiler shall have the ability to display a yellow colored, customizable maintenance notification screen. All notifications are adjustable by the installer based upon months of installation, hours of operation, and number of boiler cycles.
9) English Error codes: Boiler shall have a user interface that displays a red error screen with fault codes that are displayed in English and include a date and time stamp for ease of servicing.
10) Anti-cycling control: Boiler shall have the ability to set a time delay after a heating demand is satisfied allowing the boiler to block a new call for heat. The boiler will display an anti-cycling blocking on the screen until the time has elapsed or the water temperature drops below the anti-cycling differential parameter. The anti-cycling control parameter is adjustable by the installer.
11) Freeze protection: Boiler shall turn on the boiler and system pumps when the boiler water temperature falls below 45 degrees. When the boiler water temperature falls below 37 degrees the boiler will automatically turn on. Boiler and pumps will turn off when the boiler water temperature rises above 43 degrees.
12) Isolation valve control: Boiler shall have the ability to control a 2-way motorized control valve. Boiler shall also be able to force a fixed number of valves to always be energized regardless of the number of boilers that are firing.
13) BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.
14) Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, space heat run hours, domestic hot water run hours and ignition attempts. All data should be visible on the boiler screen.

b. The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different btu inputs without utilization of an external controller. The factory installed, internal cascade controller shall include.
   1) Lead lag: The Control module shall allow only one boiler to fire at the beginning of a call for heat. Once the lead boiler is in full fire and the control calculates that additional heat is required it will call on an additional boiler as needed.
   2) Efficiency optimization: The Control module shall allow multiple boilers to simultaneously fire at minimum firing rate in lieu of Lead/Lag.
   3) Front end loading: The Control module shall allow the cascading and functional control of several non-condensing Lochinvar products alongside the

Knight FTXL.

4) Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.

c. Boiler operating controls shall include the following devices and features.
   1) Set-Point Adjust: Set points shall be fully adjustable by the installer.
   2) Sequence of Operation: Factory installed controller to modulate burner firing rate to maintain system water temperature in response to call for heat.
   3) Sequence of Operation: Boiler shall come standard with outdoor reset control which will control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 10 deg F outside-air temperature, set supply-water temperature at 180 deg F; at 60 deg F outside-air temperature, set supply-water temperature at 140 deg F.

d. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation and include:
   1) High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.
   2) Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.
   3) Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
   4) High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.
   5) Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.
   6) Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.
   7) Optional Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.

e. Building Automation System Interface:
   1) Boiler shall have the ability to receive a 0-10V system from a building management system and control by the following: 0-10V DC input to control modulation, setpoint, enable/disable signal.
   2) Factory installed Modbus gateway interface to enable building automation system to monitor, control, and display boiler status and alarms.

6. Electrical:
   a. 120v/1ph, 60Hz.

7. Venting:
   a. Exhaust flue must be Category IV approved PVC, CPVC, PP or stainless steel sealed vent material from one of the approved manufacturers listed in the Installation and Operation manual. Boilers exhaust vent length must be able to extend to 100

equivalent feet.

b. Intake piping must be of approved material as listed in the Installation and Operations manual. Boilers intake pipe length must be able to extend to 100 equivalent feet.
c. Boiler venting and intake piping configuration shall be installed per one of the approved venting methods shown in the Installation and Operation manual.
d. Boiler shall come standard with a flue sensor to monitor and display flue gas temperature on factory provided LCD display.

8. Examination:
   a. Examine area to receive boiler for compliance with requirements for installation tolerances and other conditions affecting boiler performance. Do not proceed with installation until unsatisfactory conditions have been corrected.

9. Installation:
   a. Install boilers level and plumb, according to manufacturer's written instructions and referenced standards.
   b. Install gas-fired boilers according to NFPA 54.
   c. Install electrical devices furnished with boiler, but not specified to be factory mounted.

10. Connections:
    a. Connect gas piping and individual regulator, full size, to boiler gas-train inlet with union.
    b. Connect hot water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.
    c. Install piping from safety-relief valves to nearest floor drain.

11. Field Quality Control:
    a. Manufacturer's Field Service: Engage a factory-authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing.
       1) Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Boiler shall be commissioned by factory authorized technician. Contact local representative for factory authorized technician information.
    b. Manufacturer's representative shall supply a factory authorized service technician to start up the boilers.

12. Cleaning:
    a. Flush and clean boilers on completion of installation, according to manufacturer's written instructions.
    b. After completing boiler installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes including chips, scratches, and abrasions with manufacturer's stainless steel polish.

13. Start Up
    a. Engage a factory-authorized service representative to provide startup service. Start up to be performed only after complete boiler room operation is field verified to offer a substantial load, and complete system circulation. One-year warranty shall be handled by factory authorized tech.
    b. Complete manufacturer's installation and startup checklist are complete.

2.10 AIR-COOLED CHILLER

A. Unit Description:
    1. Provide and install as shown on the plans factory-assembled, factory-charged air-cooled scroll compressor packaged chillers in the quantity specified. Each chiller shall consist of hermetic tandem scroll compressor sets (total four compressors), brazed plate evaporator, air-cooled condenser section, microprocessor-based control system and all components necessary for controlled unit operation.
    2. Chiller shall be functionally tested at the factory to ensure trouble free field operation.

B. Design Requirements:
    1. Flow Range: The chiller shall have the ability to support variable flow range down to 40% of nominal design (based on AHRI conditions).
    2. Operating Range: The chiller shall have the ability to control leaving chilled fluid temperature from 15F to 65F.
    3. General: Provide a complete scroll compressor packaged chiller as specified herein and as shown on the drawings. The unit shall be in accordance with the standards referenced in section 1.02 and any local codes in effect.
    4. Performance: Refer to the schedule of performance on the drawings. The chiller shall be capable of stable operation to a minimum percentage of full load (without hot gas bypass) of 25%. Performance shall be in accordance with AHRI Standard 550/590.
    5. Acoustics: Sound pressure levels for the unit shall not exceed the specified levels found in the drawings. All manufacturers shall provide the necessary sound treatment (parts and labor) to meet these levels if required. Sound data shall be provided with the quotation. Test shall be in accordance with AHRI Standard 370.

C. Chiller Components:
    1. Compressor:
        a. The compressors shall be sealed hermetic, scroll type with crankcase oil heater and suction strainer. The compressor motor shall be refrigerant gas cooled, high torque, hermetic induction type, two-pole, with inherent thermal protection on all three phases and shall be mounted on RIS vibration isolator pads. The

compressors shall be equipped with an internal module providing compressor protection and communication capability.

2. Evaporator:
   a. The evaporator shall be a compact, high efficiency, dual circuit, b razed plate-to-plate type heat exchanger consisting of parallel stainless
   steel plates. Vent and drain connections shall be provided in the i nlet and outlet chilled water piping by the installing contractor.
   b. The evaporator shall be protected with an external, electric resistance heater plate and insulated with 3/4" (19mm) thick CFC and HCFC-free closed-cell flexible elastomeric foam insulation material with 100% adhesive coverage. The insulation shall have an additional outer protective layer of 3mm thick PE embossed film to provide superior damage resistance. Insulation without the protective outer film shall not be acceptable. UV resistance level shall meet or exceed a rating of 'Good' in accordance with the UNI ISO 4892 -2/94 testing method. This combination of a heater plate and insulation shall provide freeze protection down to -20F ambient air temperature.
   c. The water-side maximum design pressure shall be rated at a minimum of 435 psig (3000 kPa). Evaporators shall be designed and constructed according to, and listed by Underwriters Laboratories (UL).
3. Condenser:
   a. Condenser fans shall be propeller type arranged for vertical air discharge and individually driven by direct-drive fan motors. The fans shall be equipped with a heavy-gauge vinyl-coated fan guard. Fan motors shall be TEAO type with permanently lubricated ball bearings, inherent overload protection, three-phase, direct-drive, 1140 rpm. Each fan section shall be partitioned to avoid cross circulation.
   b. Coil shall be microchannel design and shall have a series of flat tubes containing multiple, parallel flow microchannels layered between the refrigerant manifolds. Tubes shall be 9153 aluminum alloy. Tubes made of 3102 alloy or other alloys of lower corrosion resistance shall not be accepted. Coils shall consist of a two-pass arrangement. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils shall withstand 1000+ hour acidified synthetic sea water fog (SWAAT) test (ASTM G85-02) at 120°F (49°C) with 0% fin loss and develop no leaks.
4. Refrigerant Circuit:
   a. Each of the two refrigerant circuits shall include a replaceable-core refrigerant filter-drier, sight glass with moisture indicator, liquid line solenoid valve (no exceptions), expansion valve, and insulated suction line.

5. Construction:
   a. Unit formed sheet metal components shall be painted using a cor rosion resistant paint system, for aesthetics and long-term durability. Paint system will include a base primer with a hig h-quality polyester resin topcoat. Painted galvanized parts shall be G60 or greater and finished, unabraded panel surfaces shall be c apable to be exposed to an ASTM B117 salt spray environment and exhibit no visible red rust at a minimum of 3,000 hours expo sure. Finished, abraded surfaces shall be tested per ASTM D165 4, having a mean scribe creepage not exceeding 1/16” at 1,000 hours minimum exposure to an ASTM B117 salt spray environm ent.
   b. Upper section of unit shall have protective and decorative louver s covering the coils and unit end; base section of unit shall have protective, 12 GA, PVC coated, wire grille guards and have painted steel wraps enclosing the coil end sections and piping
6. Control System:
   a. A centrally located weatherproof control panel shall contain the field power connection points, control interlock terminals, and control system. Box shall be designed in accordance with NEMA 3R rating. Power and starting components shall include factory circuit breaker for fan motors and control circuit, individual contactors for each fan motor, solid-state compressor three-phase motor overload protection, inherent fan motor overload protection and two power blocks (one per circuit) for connection to remote, contractor supplied disconnect switches. Hinged access doors shall be lockable. Barrier panels or separate enclosures are required to protect against accidental contact with line voltage when accessing the control system.
   b. Shall include optional single-point connection to a non-fused disconnect switch with through-the-door handle and compressor circuit breakers.
7. Unit Controller:
   a. An advanced DDC microprocessor unit controller with a 5-line by 22-character liquid crystal display provides the operating and protection functions. The controller shall take preemptive limiting action in case of high discharge pressure or low evaporator pressure. The controller shall contain the following features as a minimum:
   b. The unit shall be protected in two ways: (1) by alarms that shut the unit down and require manual reset to restore unit operation and (2) by limit alarms that reduce unit operation in response to some out-of-limit condition. Shut down alarms shall activate an alarm signal.
   c. Shutdown Alarms:

1) No evaporator water flow (auto-restart)
2) Sensor failures
3) Low evaporator pressure
4) Evaporator freeze protection
5) High condenser pressure
6) Outside ambient temperature (auto-restart)
7) Motor protection system

d. Limit Alarms:
1) Condenser pressure stage down, unloads unit at high discharge pressures.
2) Low ambient lockout, shuts off unit at low ambient temperatures.
3) Low evaporator pressure hold, holds stage #1 until pressure rises.
4) Low evaporator pressure unload, shuts off one compressor.

e. Unit Enable Section:
1) Enables unit operation from either local keypad, digital input, or BAS.

f. Unit Mode Selection:
1) Selects standard cooling, ice, glycol, or test operation mode.

g. Analog Inputs:
1) Reset of leaving water temperature, 4-20 mA\.
2) Current Limit.

h. Digital Inputs:
1) Unit off switch
2) Remote start/stop
3) Flow switch
4) Ice mode switch, converts operation and setpoints for ice production.
5) Motor protection

i. Digital Outputs:
1) Shutdown alarm; field wired, activates on an alarm condition, off when alarm is cleared.
2) Evaporator pump; field wired, starts pump when unit is set to start.

j. Condenser Fan Control:
1) The unit controller shall provide control of condenser fans based on compressor discharge pressure.

k. Building Automation System (BAS) Interface:
1) Factory mounted DDC controller(s) shall support operation on a BACnet®, Modbus® or LONMARK ® network via one of the data link / physical layers listed below as specified by the successful Building Automation System (BAS) supplier.

2) BACnet MS/TP master (Clause 9).
3) BACnet IP, (Annex J).
4) BACnet ISO 8802-3, (Ethernet).
5) The information communicated between the BAS and the factory mounted unit controllers shall include the reading and writing of data to allow unit monitoring, control and alarm notification as specified in the unit sequence of operation and the unit points list.
6) All communication from the chiller unit controller as specified in the points list shall be via standard BACnet objects. Proprietary BACnet objects shall not be allowed. BACnet communications shall conform to the BACnet protocol (ANSI/ASHRAE135-2001). A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided along with the unit submittal.

D. Options and Accessories:
1. Low Ambient Control: Provide fan cycling control to allow unit operation down to 32°F.
2. BAS interface module to provide interface with the BACnet MSTP protocol.
3. Compressor sound reduction – acoustic reduction blankets shall be factory installed on each compressor.
4. The following accessories, if selected, are to be included:
a. Factory-mounted thermal dispersion type flow switch.
b. Field-mounted, paddle type, chilled water flow switch field wired to the control panel.
c. Wye strainer, to be installed at the evaporator inlet and sized for the design flow rate, with perforation diameter of 0.063" with blowdown valve and Victaulic couplings (factory mounted or field installed).
d. 115V GFI convenience outlet.

2.11 PUMPS

A. Close Coupled, Vertical Inline Pump

1. General:
a. The pumps shall be of the inline, close-coupled, single stage, vertical split case design in cast iron bronze fitted construction and shall be specifically designed for quiet operation. All pump internals shall be capable of being serviced without disturbing the piping connections.
b. The pumps shall be sized for a non-overloading condition, whether it is a single pump installation, lead-lag installation or parallel pumping installation. In a parallel installation, one pump must be able to operate in a non-overload condition while the other pump is turned off. The pump submittals must show this situation, complete with parallel pumping and system curves.
c. The dimensions of the suction and discharge connections of each pump shall not be less

than those of the scheduled pumps shown on the plans.

d. The pump manufacturer shall be ISO-9001 certified.

2. Pump Casing:
   a. Pump casing shall be cast iron, suitable for 175 psi (1206 kPa) working pressure at 140°F (60°C). Ductile iron pump casings are suitable for pressures to 250 psi (1724 kPa). The casing shall be hydrostatically tested to 150% maximum working pressure. The casing shall be radially split to allow removal of the rotating element without disturbing the pipe connections. The casing suction and discharge connections shall be the same size and shall be provided with drilled and tapped seal vent and pressure gauge connections.

3. Impeller:
   a. Pump impeller shall be bronze, fully enclosed type. Impeller shall be dynamically balanced.

4. Seal:
   a. Mechanical Seal shall be single spring inside type with carbon against Ceramic faces. EPDM elastomer with stainless steel spring and hardware shall be provided. Seal vent line shall be factory installed and shall be piped from the seal area to the pump suction connection.

5. Shaft:
   a. A bronze shaft sleeve, extending the full length of the mechanical seal area, shall be provided.

6. Motor:
   a. The motor shall meet the scheduled horsepower, speed, voltage, and enclosure design. The motor shall have heavy-duty grease lubricated ball bearings to offset the additional bearing loads associated with closed coupled pump design. The motor shall be non-overloading at any point on the pump curve and shall meet NEMA specification.

7. Capacity, Manufacturer, and Accessories:
   a. See Drawings.

2.12 VARIABLE FREQUENCE DRIVES

A. Variable Frequency Drives:

1. General:
   a. Description:
      1) This specification is to cover a complete Variable Frequency Drive (VFD aka: VSD, AFD, ASD, Inverter, AC Drive, et al) consisting of a pulse width modulated (PWM) inverter designed for use with a standard NEMA Design B induction motor.
      2) The drive manufacturer shall supply the drive and all necessary options as herein specified. The manufacturer shall have been engaged in the production

of this type of equipment for a minimum of twenty years. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable. Drive manufacturers who do not build their own power boards and assemblies, or do not have full control of the power board manufacturing and quality control, shall be considered as a "brand labeled" drive. All VFDs installed on this project shall be from the same manufacturer.

2. Quality Assurance:
   a. Referenced Standards and Guidelines:
      1) Institute of Electrical and Electronic Engineers (IEEE)
         a) IEEE 519-2014, IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems.
      2) Underwriters Laboratories (as appropriate)
         a) UL 508A
         b) UL 61800-5-1
      3) National Electrical Manufacturer's Association (NEMA)
         a) ICS 7.0, AC Adjustable Speed Drives
      4) CSA Group
         a) CSA C22.2 No. 274
      5) International Electrotechnical Commission (IEC)
         a) EN/IEC 61800-3
      6) National Electric Code (NEC)
         a) NEC 430.120, Adjustable-Speed Drive Systems
      7) International Building Code (IBC)
         a) IBC 2018 Seismic – referencing ASC 7-16 and ICC AC-156
   b. Qualifications:
      1) VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for external input fuses.
      2) CE Mark – The base VFD shall conform to the European Union Electromagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with filters to bring the drive in compliance with the First Environment levels.
      3) The entire VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2018 International Building Code (IBC):
         a) VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
         b) Seismic importance factor of 1.5, and minimum 2.5 S_{DS} rating is required.
         c) Ratings shall be based upon actual shake test data as defined by ICC AC-156, via all three axis of motion.
         d) Seismic certification of equipment and components shall be provided by HCAI (formerly OSHPD) preapproval.

4) Factory authorized start up and owner training should be provided locally upon request.

3. Submittals:
   a. Submittals shall include the following information:
      1) Outline dimensions, conduit entry locations and weight.
      2) Customer connection and power wiring diagrams.
      3) Complete technical product description include a 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.

4. Building Information Modeling (Bim):
   a. BIM objects shall contain IFC parameters and associated data applicable to building system requirements. These elements shall support the analytic process including size, clearance, location, mounting heights, and system information where applicable.
   b. VFD BIM models shall contain as a minimum the following attributes:
      1) Input voltage
      2) Current rating
      3) Model number
      4) Manufacturer
      5) Enclosure type

B. Products:

1. Variable Frequency Drives:
   a. The VFD package as specified herein and defined on the VFD schedule shall be enclosed in a UL Type enclosure (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer in an ISO9001 facility.
   b. 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) VFDs shall be capable of continuous full load operation under the following environmental operating conditions:
         a) -15 to 40° C (5 to 104° F) ambient temperature. Operation to 50° C shall be allowed with a 10% reduction from VFD full load current.
         b) Altitude 0 to 3300 feet above sea level. Operation to 6600 shall be allowed with a 10% reduction from VFD full load current.
         c) Humidity 5 to 95%, non-condensing.
   c. All VFDs shall have the following standard features:
      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, Supervisory, external fault status, drive name, drive fault contact info and override 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 drive shall generate a QR code, which contains drive identification data, information on the latest events, and values of status and counter parameters.
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 without the use of alpha-numerical parameters, for commissioning the drive 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) Bluetooth connectivity shall be capable of being switched.

d. All VFDs shall have the following standard features:
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. Reference the drive schedule to determine if additional harmonic mitigation is required for the system to comply with IEEE 519-2014.
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, 135% 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) 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).
15) 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

e. 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) A Fault Logger that stores the last 16 faults in non-volatile memory
a) Events shall include, but not limited to: Warning messages, checksum mismatch, run permissive open, start interlock open, automatic reset of

a fault, power applied, auto start command, auto stop command, modulating started, and modulating stopped.

b) The date and time of each event's start and completion points shall be stored in the Event Logger.

c) The drive shall also provide the user the ability to configure what events to log for application specific requirements.

3) Programmable start method. Start method shall be selectable based on the application and function even if the motor was freewheeling in the reverse direction: 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) The following three-phase AC motor technologies shall be compatible:
   a) Asynchronous induction motors
   b) Permanent magnet synchronous (non-salient pole) motor
   c) Synchronous reluctance motor (SynRM)
   d) Permanent magnet assisted synchronous reluctance motor (PMaSynRM)

6) 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.

7) Motor disconnect detection function enables the drive to detect when an output disconnect is opened, disable the drive output, and provide an indication message. Drives without this functionality shall have a disconnect switch auxiliary contact wired through dedicated conduit back to the drive enable control circuit.

8) Motor phase order shall be changeable through software interface.

9) Advanced power metering abilities shall be included in the drive and must be available over network communications. 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.

10) 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.

11) DC bus voltage ripple function shall provide a DC voltage reference for troubleshooting AC line issues or bus capacitor health.

12) Run permissive circuit - There shall be a run permissive circuit for damper or valve control. The drive shall provide a relay output to the damper actuator, monitor end-switch status, and start running the motor based on application requirements. Damper control shall include the following configurable features fully functional in both Hand and Auto modes:
    a) A timeout function that identifies and annunciates a specific warning message when a damper has not opened or closed within the allotted time.
    b) Ability to interface with both damper open and damper closed end-switches on a single damper actuator.
    c) Sequence control that runs the fan initially at a fixed speed before commanding a discharge air damper to open. Required for all applications feeding a common plenum/space to prevent the fan from freewheeling backwards while damper strokes open.
    d) Multiple damper sequence control to support units with discharge air and outside air dampers. The drive shall command and verify the outside air damper is open before ramping the fan to a fixed speed, and then commanding the outside air damper open.
    e) Time based damper control for when an end-switch is not provided. For units with outside air and discharge air dampers, both dampers should have independent time based control capability.
13) 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.
14) 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.
15) The drive shall provide automatic protections to allow uninterrupted operations at a reduced speed or switching frequency:
    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.
    b) The drive shall include a temperature limit that when exceeded will reduce the drive output current.
    c) Input phase loss protection shall be provided, whereas the output current is automatically derated by 50% if an input phase loss is detected by the drive.
16) 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
17) 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.

18) Three (3) programmable critical frequency lockout ranges to prevent the drive from operating the load continuously at an unstable speed/load.
19) The drive shall have three methods to control constant frequency/speed references.
    a) Seven (7) programmable preset frequencies/speeds using (3) inputs.
    b) Six (6) different programable preset frequencies/speed tied to 6 independent control inputs and requires an additional start command.
    c) Six (6) different programable preset frequencies/speed tied to 6 independent control inputs and does not require any additional start command input.
20) Two independently adjustable accel and decel ramps sets with 1 – 1800 seconds adjustable time ramps.
21) 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.
22) 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.
23) 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.
24) 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.
25) 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 passcode 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.

26) The drive shall have multi-pump functionality and an intelligent floating leader/follower configuration, so no one drive takes down the system, 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

27) The drive shall have pump protection functions for flow and pressure to avoid damages to the pump such as dry pump protection, min/max flow and pressure protection.

f. Security Features
   1) The drive manufacture shall clearly define cybersecurity capabilities for their products.
   2) The drive shall include passcode protection against parameter changes.
      a) There shall be multiple levels of passcode protection including: End User, Service, Advanced, and Override.
      b) The drive shall support a customer generated unique passcode between 0 and 99,999,999.
      c) The drive shall log an event whenever the drive passcode 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 do the following:

a) Be individually disabled (via parameter) for drives mounted in public areas to prevent unauthorized changes.
b) Require a second button press of “Hand” or “Off” within 5 seconds of the original selection to confirm the change and prevent accidental transition out of “Auto” mode.

g. 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 independent end of line (EOL) termination and biasing switches for EIA-485 networks.
3) The drive shall contain EIA-485 network self-diagnostics to assist in troubleshooting issues such as incorrect polarity, incorrect baud rate, noise on the wire or addressing errors.
4) 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
5) The drive shall not require a power cycle after communication parameters have been updated.
6) 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.
7) 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.
8) 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.

h. 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 UL508A label. Disconnect packages manufactured by anyone other than the drive manufacturer, are not acceptable.

C. Execution:

1. Installation
   a. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.
   b. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

2. Start-Up
   a. Factory start-up shall be provided for each drive by a factory authorized service center. A start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

3. Product Support
   a. Factory trained application engineering and service personnel that are thoroughly familiar with the VFD products offered 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 shall be available. Technical support offered only through the local sales office is not acceptable.
   b. Training shall include installation, programming, and operation of the VFD, bypass and serial communication. Factory authorized start up and owner training to be provided locally upon request.

4. Warranty
   a. The VFD Product Warranty shall be 30 months from the date of factory shipment. The warranty shall include all parts, labor, travel time and expenses. A toll free 24/365 technical support line shall be available.

2.13 DUCTLESS SPLIT SYSTEMS

A. Ductless Split System - Wall-Mounted Units
¾ to 3 ton nominal cooling only or heat pump outdoor unit

1. General:
   a. Indoor, direct-expansion, wall-mounted fan coil. Unit shall be complete with cooling/heating coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and integral temperature sensing. Unit shall be furnished with integral wall mounting bracket and mounting hardware. Unit shall be rated per ARI Standards 210/240 and UL labeled.

2. Unit Cabinet:
   a. Cabinet discharge and inlet grilles shall be attractively styled, high-impact polystyrene. Cabinet shall be fully insulated for improved thermal and acoustic

performance.

3. Fans:
   a. Fan shall be tangential direct-drive blower type with air intake at the top of the unit and discharge at the bottom front. Automatic, motor-driven vertical air sweep shall be provided standard.
   b. Air sweep operation shall be user selectable. The vertical sweep may be adjusted (using the remote control) and the horizontal air direction may be set manually.

4. Coil:
   a. Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a drain connection for hose attachment to remove condensate. Condensate pan shall have internal trap.

5. Motors:
   a. Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection. Fan motors shall be 3-speed.

6. Controls:
   a. Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self-diagnostics. The temperature control range shall be from 62° F to 84° F.
   b. The unit shall have the following functions as a minimum:
      1) An automatic restart after power failure at the same operating conditions as at failure.
      2) A timer function, to provide a minimum 24-hour timer cycle for system Auto Start/Stop.
      3) Temperature-sensing controls shall sense return air temperature.
      4) Indoor coil freeze protection.
      5) Wireless infrared remote control to enter set points and operating conditions.
      6) Automatic air sweep control to provide on or off activation of air sweep louvers.
      7) Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
      8) Fan-only operation to provide room air circulation when no cooling is required.
      9) Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit.
      10) Fan speed control shall be user-selectable: high, medium, low, or microprocessor controlled automatic operation during all operating modes.
      11) Automatic heating-to-cooling changeover in heat pump mode. Control shall include deadband to prevent rapid mode cycling between heating and cooling.
      12) Indoor coil high temperature protection shall be provided to detect excessive indoor discharge temperature when unit is in heat pump mode.

7. Filters:
   a. Unit shall have filter track with factory-supplied cleanable filters.

8. Electrical Requirements:
   a. Power is supplied from outdoor unit.

9. Special Features (Field Installed, if necessary):
   a. Condensate Pump: The condensate pump shall remove condensate from the drain pan when gravity drainage cannot be used. Pump shall be designed for quiet operation. Pump shall consist of two parts; an internal reservoir/sensor assembly, and a remote sound-shielded pump assembly. A liquid level sensor in the reservoir shall stop cooling operation if the liquid level in the reservoir is unacceptable.

10. Warranty:
    a. Minimum 1-year parts limited warranty.

B. Ductless Split System - Outdoor Units
¾ to 3 Ton Nominal Cooling Capacity / ¾ to 3 Ton Nominal Heating Capacity

1. Outdoor Units:
   a. General:
      1) Factory assembled, single piece, air-cooled outdoor unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, and the compressor.
      2) Units shall consist of a rotary compressor, an air-cooled coil, propeller-type draw-through outdoor fan, reversing valve (HP), accumulator (HP units), metering device(s), and control box. Units shall discharge air horizontally as shown on the contract drawings. Units shall function as the outdoor component of an air-to-air cooling only, or heat pump system.
      3) Units shall be used in a refrigeration circuit matched to duct-free cooling only or heat pump fan coil units.
   b. Unit Cabinet:
      1) Unit cabinet shall be constructed of galvanized steel, bonderized and coated with a baked-enamel finish on inside and outside.
      2) Unit access panels shall be removable with minimal screws and shall provide full access to the compressor, fan, and control components.
      3) Outdoor compartment shall be isolated and have an acoustic lining to assure quiet operation.
   c. Fans:
      1) Outdoor fans shall be direct-drive propeller type, and shall discharge air horizontally. Fans shall draw air through the outdoor coil.
      2) Outdoor fan motors shall be totally-enclosed, single phase motors with class B insulation and permanently-lubricated ball bearings. Motor shall be protected by internal thermal overload protection.
      3) Shaft shall have inherent corrosion resistance.
      4) Fan blades shall be non-metallic and shall be statically and dynamically balanced.
      5) Outdoor fan openings shall be equipped with PVC metal/mesh coated protection grille over fan.

d. Compressor:
   1) Compressor shall be fully hermetic rotary type.
   2) Compressor shall be equipped with oil system, operating oil charge, and motor. Internal overloads shall protect the compressor from over-temperature and over-current.
   3) Motor shall be NEMA rated class F, suitable for operation in a refrigerant atmosphere.
   4) Compressor assembly shall be installed on rubber vibration isolators.

e. Outdoor Coil:
   1) Coil shall be constructed of aluminum fins mechanically bonded to seamless copper tubes, which are cleaned, dehydrated, and sealed.

f. Refrigeration Components:
   1) Refrigerant circuit components shall include brass external liquid line service valve with service gage port connections, suction line service valve with service gage connection port, service gage port connections on compressor suction and discharge lines with Schrader type fittings with brass caps, accumulator, reversing valve. Provide tamper proof port caps.

g. Controls and Safeties:
   1) Operating controls and safeties shall be factory selected, assembled, and tested. The minimum control functions shall include the following:
      a) A time delay control sequence is provided standard through the fan coil board.
      b) Automatic outdoor-fan motor protection.
      c) System diagnostics.
      d) Compressor motor current and temperature overload protection.
      e) Outdoor fan failure protection.

h. Electrical Requirements:
   1) Unit electrical power shall be a single point connection.
   2) Unit control voltage to the indoor-fan coil shall be 24 VDC.
   3) All power and control siring must be installed per NEC and all local electrical codes.
   4) Unit shall have high-and low-voltage terminal block connections.

i. Special Features (Field Installed):
   1) Low-Ambient Kit: Control shall regulate fan-motor cycles in response to saturated condensing temperature of the unit. The control shall be capable of maintaining a condensing temperature of 100° F ± 10° F, with outdoor temperatures to 20° F. Installation of kit shall not require changing the outdoor fan motor.
   2) Crankcase Heater.

j. Warranty:
   1) 1-Year parts and 5-Year compressor warranty.

2.14 UPBLAST EXHAUST FANS

A. General

1. Description:
   a. Fan shall be a single width, single inlet, backward inclined flat blade, belt driven centrifugal vent set.
2. Certifications:
   a. Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL/cUL 705) for US and Canada. For restaurant applications, fan shall be listed by Underwriters Laboratories (UL/cUL 762) for US and Canada. For smoke control applications, fan shall be listed by Underwriters Laboratories (Power Ventilator for Smoke Control Systems) for US and Canada. Fan shall bear the AMCA certified ratings seal for air performance.
3. Construction:
   a. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The scroll wrapper shall be a minimum 14-gauge steel and the scroll side panels shall be a minimum 12-gauge steel. The entire fan housing shall have continuously welded seams for leakproof operation. A performance cut-off shall be furnished to prevent the recirculation of air in the fan housing. The fan housing shall be field rotatable to any one of eight discharge positions and shall have a minimum 1-1/2-inch outlet discharge flange. Bearing support shall be minimum 10-gauge welded steel. Side access inspection ports shall be provided with quick release latches for access to the motor compartment without removing the weather cover. Lifting lugs shall be provided for ease of installation. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA certified transit tested packaging.
4. Coating:
   a. Steel fan components shall be Lorenized™ with an electrostatically applied, baked polyester powder coating. Each component shall be subject to a five stage environmentally friendly wash system, followed by a minimum 2 mil thick baked powder finish. Paint must exceed 1,000-hour salt spray under ASTM B117 test method.
5. Wheel:
   a. Wheel shall be steel centrifugal backward inclined, non-overloading flat blade type. Blades shall be continuously welded to the backplate and deep spun inlet shroud. Wheel hub shall be keyed and securely attached to the fan shaft. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05, *Balance Quality and Vibration Levels for Fans*.
6. Motor:
   a. Motor shall be Nema design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure.
7. Bearings:
   a. Bearings shall be designed and tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball or roller type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.
8. Blower Shaft:
   a. Blower shaft shall be AISI C-1045 hot rolled and accurately turned, ground and

polished. Shafting shall be sized for a critical speed of at least 125% of maximum RPM.

9. Belts and Drives:
   a. Belts shall be oil and heat resistant, static conducting. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

2.15 UTILITY EXHAUST FANS

A. General
   1. Description:
      a. Fan shall be a single width, single inlet, backward inclined flat blade, belt driven centrifugal vent set.
   2. Certifications:
      a. Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL/cUL 705) for US and Canada. For restaurant applications, fan shall be listed by Underwriters Laboratories (UL/cUL 762) for US and Canada. For smoke control applications, fan shall be listed by Underwriters Laboratories (Power Ventilator for Smoke Control Systems) for US and Canada. Fan shall bear the AMCA certified ratings seal for air performance.
   3. Construction:
      a. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The scroll wrapper shall be a minimum 14 gauge steel and the scroll side panels shall be a minimum 12 gauge steel. The entire fan housing shall have continuously welded seams for leakproof operation. A performance cut-off shall be furnished to prevent the recirculation of air in the fan housing. The fan housing shall be field rotatable to any one of eight discharge positions and shall have a minimum 1-1/2 inch outlet discharge flange. Bearing support shall be minimum 10 gauge welded steel. Side access inspection ports shall be provided with quick release latches for access to the motor compartment without removing the weather cover. Lifting lugs shall be provided for ease of installation. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA certified transit tested packaging.
   4. Coating:
      a. Steel fan components shall be LorenizedTM with an electrostatically applied, baked polyester powder coating. Each component shall be subject to a five stage environmentally friendly wash system, followed by a minimum 2 mil thick baked powder finish. Paint must exceed 1,000 hour salt spray under ASTM B117 test method.
   5. Wheel:
      a. Wheel shall be steel centrifugal backward inclined, non-overloading flat blade type. Blades shall be continuously welded to the backplate and deep spun inlet shroud. Wheel hub shall be keyed and securely attached to the fan shaft. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-05,

Balance Quality and Vibration Levels for Fans.

6. Motor:
   a. Motor shall be Nema design B with class B insulation rated for continuous duty and furnished at the specified voltage, phase and enclosure.
7. Bearings:
   a. Bearings shall be designed and tested specifically for use in air handling applications. Construction shall be heavy duty regreasable ball or roller type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.
8. Blower Shaft:
   a. Blower shaft shall be AISI C-1045 hot rolled and accurately turned, ground and polished. Shafting shall be sized for a critical speed of at least 125% of maximum RPM.
9. Belts and Drives:
   a. Belts shall be oil and heat resistant, static conducting. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150% of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

2.16 HUMIDIFIER

A. General
   1. Description:
      a. Air humidification apparatus for the production of aseptic steam, with gas burner technology, supplied with mains drinking water.
      b. System commissioning performed by [manufacturer's technical personnel.
   2. Product:
      a. Stand-alone isothermal humidifier with gas burner for the production of steam at atmospheric pressure using city drinking water.
      b. The water is heated via a heat exchanger containing the burner combustion head, producing sterile steam.
      c. The apparatus shall be able to operate with natural gas (G20 or G25) or LPG (G31); the initial configuration shall be performed in the field by setting software parameters and without replacing any mechanical parts.
      d. The humidifier shall be able to operate within the following temperature range: -40°C to +45°C.
      e. Steam production, water drain and refill shall be managed by the control program completely automatically according to actual feedwater conductivity, without the need for prior analysis or settings.
   3. Features:
      a. Painted steel supporting structure with separate sections for the water circuit and the electrical parts, front and side panels that can be removed for maintenance.
      b. Electrical section with electrical panel including electrical components and electronic control.
      c. The steam production boiler shall be built using AISI 304 stainless steel.
      d. The heat exchanger immersed in the water shall be thin AISI316L stainless steel

with a minimum heat exchange efficiency of 94%.

e. The quantity of steam produced shall be modulated continuously, with a minimum flow-rate not exceeding 25%.
f. The water level shall be controlled by a suitable three-level sensor.
g. Any excess foam on the surface of the water shall be detected and managed by a suitable device inside the boiler. SOLUTIONS WITHOUT PROTECTION AGAINST EMISSION OF BOILING WATER ARE NOT PERMITTED. The same device shall also act as an additional safety level sensor.
h. In the event of inactivity, the water shall be automatically drained after 72 h (parameter that can be set by the user).
i. At least two frost protection safety checks shall be provided in the event of a fall in temperature, before completely emptying the boiler automatically due to inactivity.
j. In the event of temperatures below 3°C, the automatic boiler drain shall be controlled by a system that is independent of the unit's power supply (a mechanical NO valve independent of the electrical circuit and functioning even if the unit is switched off).
k. The unit installed indoors shall have two sides accessible for maintenance and be able to be positioned close to two walls.
l. The unit installed outdoors shall be able to be positioned on a raised support base, with the water, power supply and drain connections at the bottom of the unit.

4. Controls:
   a. The apparatus shall be managed completely automatically by an electronic microprocessor controller. Steam production shall be modulated continuously according to the input signal.
   b. Input signal from probe or external controller: 0-1V, 0-10V, 0-20mA, 4-20mA, ON/OFF contact, NTC.
   c. An external enabling input and at least 4 programmable relays are required for remote signaling of alarm status, production status, activation of the steam blower.
   d. An input for a second "limit" humidity probe is required to CONTINUOUSLY MODULATE PRODUCTION based on the humidity downstream in the duct, in order to prevent condensation during temperature transients. A SIMPLE ON/OFF ENABLING INPUT BASED ON A THRESHOLD IS NOT ACCEPTABLE FOR THIS PURPOSE.
   e. The minimum required control algorithms, which can be selected during installation, are: stand-alone with room probe, stand-alone with main probe + modulating limit probe, stand-alone with two probes (average); secondary with external proportional voltage or current signal, with external signal + local limit probe, ON/OFF from voltage-free contact, with NTC temperature probe for steam baths.
   f. The user interface shall feature a colour touch screen graphic display for programming and monitoring unit status, the set and measured humidity level, steam production, current draw, water conductivity, parameters and alarms using text and icons.
   g. The web server function shall be available for connectivity to the local Ethernet network.
   h. It shall be connectable to other similar units in *main-secondary* i.e. "mirror" mode so as to extend capacity, including the "automatic backup" and "rotation" functions to distribute wear equally across several humidifiers operating in the system.

i. It shall be connectable to multiple wireless probes to avoid wiring in critical installations; the probes can be assigned a weight for average measurements.
j. Initial configuration shall be guided via wizard.
k. The following shall be included: complete diagnostics, alarm log downloadable via USB port for diagnosis; messages for preventive maintenance.
l. It shall include daily and weekly programming of operation with differentiated set points.
m. Water pre-heating function to reduce time to reach production (programmable pre-heating set point).

5. Performance Data:
   a. Relative humidity control accuracy shall be up to +/- 3%.
   b. Maximum flow-rate shall be settable by parameter, with continuous production control between 25% and 100% of the maximum set capacity (12.5% for models with two burners).
6. Safety, Savings, and Hygiene:
   a. The burner shall be a negative pressure premix model with double safety shutter for the gas and negative pressure sensor on the air intake.
   b. The flame control board shall comply with CE, TÜV DVGW, ETL, AGA standards.
   c. The flue gas temperature shall be monitored by means of a specific temperature sensor to detect combustion problems or the need to clean the heat exchanger.
   d. In addition, the flue gas exhaust system shall be equipped with a mechanical thermal circuit breaker with manual reset to detect overheating and interrupt operation independently of the electronic controller.
   e. The apparatus shall be equipped with a conductivity meter in the feedwater supply circuit and a suitable software algorithm to optimize water change and prevent corrosion based on actual water quality, allowing significant savings in water consumption. SOLUTIONS THAT ONLY ALLOW MANUAL SETTING OF WATER HARDNESS DURING INSTALLATION ARE NOT ACCEPTABLE, THE SYSTEM MUST BE SELF-ADAPTIVE.
   f. Automatic water draining due to inactivity shall be factory-set every 3 days by parameter, however can be modified in the field to comply with any local regulations, so as to avoid hygiene problems due to stagnant water.
   g. The device shall be equipped with an automatic frost protection feature.
7. Interface:
   a. BACnet, Modbus, CAREL protocols for BMS and remote control via RS485 serial; BACnet and Modbus protocols over Ethernet. Without requiring external devices.
   b. USB for programming, updating, parameter duplication, diagnostic logs.
   c. Ethernet port.
   d. RS485 serial port.
   e. The humidifier shall be able to be monitored and managed remotely using a cloud service operating via Ethernet or 4G network in plug&play mode.
8. Accessories:
   a. Steam delivery hoses, food safety certified quality, with embedded steel spiral to prevent choking, diameters 22, 30, 40 and 80 mm.
   b. Stainless steel duct steam distributors with diameters 22, 30 and 40 mm, lengths between 35 and 205 cm, flow-rates from 1 to 40 kg/h, with separate condensate

drain.

c. 10 mm drain pipes for condensate and 40/50 mm for humidifier water.

d. Wide range of relative humidity and temperature sensors, duct and room models, ranges 10-90% rH or 0-100% rH, with current or voltage signal.

e. Provide with 5 micron particulate filter to be placed after the manual fill valve 1 to trap solid impurities.

2.17 SLOTTED FUME HOOD

A. General

1. Furnish slotted intake vertical exhaust hood with discharge diameter and slot spacing sized to meet the capacities as called for in the plans and specifications
2. The hood shall be fabricated of minimum 18 gauge galvanized or stainless steel, or .063 aluminum as indicated on plans. The baffles between slots shall be installed using fasteners suitable to facilitate removal for cleaning and repositioning to enhance intake velocity, if necessary.
3. The fume hood shall be the standard product of an exhaust system manufacturer, completely factory assembled, including eccentric tapered riser to facilitate wall abutting mount, with crimped and beaded discharge collar for secure and air-tight duct connection.

2.18 CONTROL SYSTEM

A. General:

1. The Mechanical Contractor shall be responsible for a complete and operable control system, including equipment, installation, and accessories required to perform the required control functions. All control conduit and wiring shall be furnished by the Electrical Contractor. Thermostats, sub-base switches, remote control devices, etc., shall be supplied by the Mechanical Contractor and installed and connected by the Mechanical Contractor. The Mechanical Contractor shall furnish the Electrical Contractor with wiring diagrams for all mechanical equipment and controls.
2. The control system shall a direct digital controls (DDC) type. See specification Section 230900 for details.
3. The base bid shall include standalone DDC controls. Bid Alternate #2 shall include front end graphics and adjustable setpoints.

B. Control Equipment and Accessories:

1. Control Dampers:

a. All control dampers are to be furnished under this section, except those specified to be furnished with the air handling units. Damper blades shall be fabricated of 22-gauge galvanized sheet steel and frames shall be not less than 16-gauge galvanized steel. Blades shall be maximum 10 inches wide, 50 inches long, and shall be provided with neoprene gasketed edges and oilite bronze or nylon bearings. Dampers shall be ultra-low leakage, opposed blade type for proportional action and parallel blade type for two-position action. Leakage performance shall be a maximum of 3 cfm per sq, ft. @ a pressure differential of 1" w.g. Provide damper operators for all motorized dampers

and louvers. Belimo or approved equal. Submittals shall include leakage and pressure drop data for all control dampers. All outside air dampers shall fail closed.

2. Equipment Control Schematics:
   a. See Drawings for schematics and sequence of operations.

PART 3 - EXECUTION

3.1 WORKMANSHIP

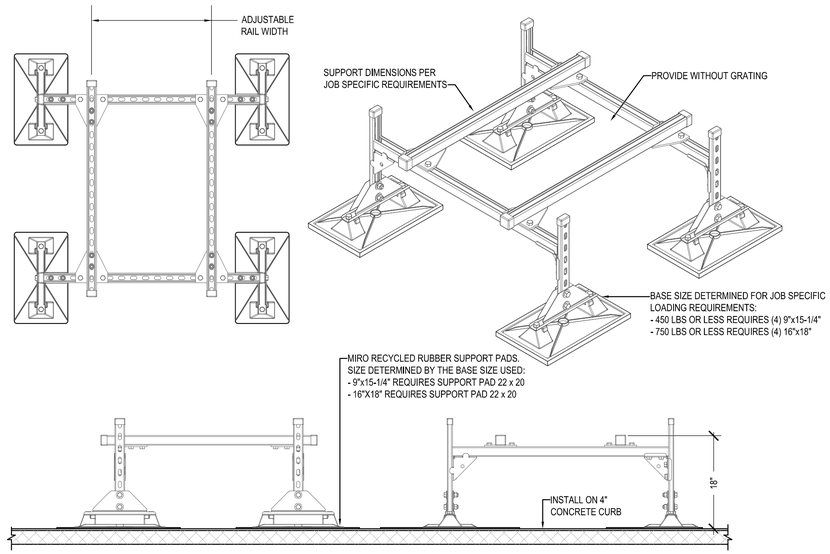
A. General:

1. Install all materials and equipment as shown and in strict accordance with the applicable codes for the State and/or city. Plans do not attempt to show exact details of all piping and ductwork, and no extra payment will be allowed for offsets required due to obstructions by other trades. All work shall be done in a neat and orderly fashion and left in a condition satisfactory to the Architect/Engineer.
2. All piping shall be run parallel or perpendicular to established building lines. Install piping so as to allow for expansion. Install all valves with stems horizontal or above. Install air vents at all high points. Provide all piping which passes through walls, floors, or ceilings with standard weight pipe sleeves.
3. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Gasket shall be molded and produced by the grooved coupling manufacturer. Verify gasket grade is suitable for the intended service. The grooved coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools, application of groove, and installation of groove end products.
4. Install the grooved piping and fittings in accordance with the latest recommendations as published by the manufacturer. Pipe shall be square cut, +/-0.030", properly deburred and cleaned. Mark pipe ends at the required location using a gauge supplied by the Manufacturer to ensure full insertion into the coupling or fitting during assembly. Use a manufacturer's tool with proper sized jaw for pressing.

B. Insulation:

1. All piping insulation shall be applied over clean, dry surfaces after system has been pressure tested and any leaks corrected. Finished appearance of all insulation shall be smooth and continuous. Provide coat of insulating cement where needed to obtain this result.

END OF SECTION 23 0100



NOTES:

1. PROVIDE WITH MIRO INDUSTRIES MODEL HD, HEAVY DUTY MECHANICAL GALVANIZED SUPPORT WITH ADJUSTABLE SUPPORT LEGS AND RAIL WIDTH
2. BOLT EQUIPMENT TO CONCRETE CURB, A MINIMUM OF (4) LOCATIONS
3. APPROVED ALTERNATE MANUFACTURERS: UNISTRUT AND ROOF-PRO

1 HEAT PUMP UNIT PLATFORM DETAIL

NOT TO SCALE (EQUIPMENT WEIGHTS UP TO 750 LBS)

A QUALIFIED WATER TREATMENT CONTRACTOR SHALL BE UTILIZED TO FURNISH THE CLEANING MATERIAL AND SUPERVISE THE FLUSHING AND TREATMENT OF THE SYSTEM. APPROVED WATER TREATMENT CONTRACTORS MUST SHOW PROOF OF SIMILAR SERVICE FOR NO LESS THAN 3 YEARS, AND SHALL HAVE FULL-TIME SERVICE PERSONNEL LOCATED WITHIN ONE-HOUR FROM THE JOB SITE. MONITORING AND TREATMENT OF THE SYSTEM SHALL BE PROVIDED FOR A PERIOD OF ONE YEAR FOLLOWING FINAL ACCEPTANCE OF BUILDING AND SYSTEM.

DESCRIPTION OF WORK

1. LEAK CHECK AND INITIAL SYSTEM CLEANING:

   -ONCE THE ENTIRE SYSTEM HAS BEEN COMPLETELY INSTALLED, THE HEATING WATER DISTRIBUTION SYSTEM SHALL BE COMPLETELY CLEANED AND CHECKED FOR LEAKS. THE WATER TREATMENT CONTRACTOR SHALL ADD INITIAL CHEMICAL CLEANING AGENT TO FACILITATE FLUSHING AND TO PREVENT CORROSION DURING THE LEAK CHECK PROCESS. THE SYSTEM SHALL BE FREE OF ALL CUTTING OILS AND OTHER DEBRIS. THE WATER TREATMENT CONTRACTOR SHALL FILL THE HEATING SYSTEM WITH CLEAN, FRESH WATER AND THOROUGHLY CHECK SYSTEM PIPING FOR LEAKS. FOLLOWING THE LEAK CHECK, THE CLOSED SYSTEM SHALL BE FLUSHED UNTIL THE LEAVING WATER RUNS CLEAR. DURING THIS PROCESS, ONE OF THE HOSES AT EACH REHEAT COIL AND AIR HANDLER WILL BE CONNECTED TO BYPASS THE REHEAT COIL, FLOW STRAINER, AND FLOW CONTROL DEVICE. THE WATER TREATMENT CONTRACTOR SHALL ENSURE THAT SYSTEMS NOT BE LEFT DRY DURING SYSTEM DRAIN-DOWN.

2. HEATING WATER SYSTEM CHEMICAL TREATMENT:

   -FILL SYSTEM WITH A SOLUTION OF 10% BY WEIGHT OF A HEAVY DUTY ALKALINE LIQUID CLEANER. THE CLEANER SHALL BE CAPABLE OF WETTING AND PENETRATING HEAVY SOIL DEPOSITS OF OIL OR GREASE, AND OF KEEPING THESE PRODUCTS IN SUSPENSION.

   -HEAT SOLUTION TO 180° F AND CIRCULATE FOR A MINIMUM OF 8 HOURS, THEN FLUSH SYSTEM WITH CLEAN FRESH WATER UNTIL ALL SOLIDS HAVE BEEN CLEANED FROM THE SYSTEM. CLEAN ALL STRAINERS IN SYSTEM.

   -FOLLOWING CLEAN AND FLUSH PROCESS, RE-CONNECT REHEAT COIL HOSE KITS FOR NORMAL OPERATION AND INSPECT ALL FLOW CONTROL DEVICES AND STRAINERS. WHEN NECESSARY, THESE COMPONENTS SHALL BE FLUSHED TO ENSURE UNOBSTRUCTED FLOW TO EACH REHEAT COIL.

   -THE WATER TREATMENT CONTRACTOR SHALL REFILL SYSTEM WITH A MIXTURE OF 70% VOLUME OF CLEAN WATER AND 30% VOLUME OF DOWFROST HD PROPYLENE GLYCOL WITH BUILT-IN CHEMICAL INHIBITOR.

3. AT THE CONCLUSION OF CLEANING AND TREATING, THE WATER TREATMENT CONTRACTOR SHALL CERTIFY IN WRITING THAT THE SYSTEM HAS BEEN CLEANED AND TREATED AS SPECIFIED.

4. AT THE END OF ONE YEAR, THE SYSTEM SHALL AGAIN BE CHECKED AND REFILLED AS REQUIRED TO MEET THE ABOVE SPECIFICATIONS. SERVICE DURING THE ONE-YEAR WARRANTY PERIOD SHALL BE AS REQUIRED TO MAINTAIN ABOVE SPECIFICATIONS.

2 HEATING WATER SYSTEM FLUSHING & TREATMENT

NOT TO SCALE

A QUALIFIED WATER TREATMENT CONTRACTOR SHALL BE UTILIZED TO FURNISH THE CLEANING MATERIAL AND SUPERVISE THE FLUSHING AND TREATMENT OF THE SYSTEM. APPROVED WATER TREATMENT CONTRACTORS MUST SHOW PROOF OF SIMILAR SERVICE FOR NO LESS THAN 3 YEARS, AND SHALL HAVE FULL-TIME SERVICE PERSONNEL LOCATED WITHIN ONE-HOUR FROM THE JOB SITE. MONITORING AND TREATMENT OF THE SYSTEM SHALL BE PROVIDED FOR A PERIOD OF ONE YEAR FOLLOWING FINAL ACCEPTANCE OF BUILDING AND SYSTEM.

DESCRIPTION OF WORK

1. LEAK CHECK AND INITIAL SYSTEM CLEANING:

   -ONCE THE ENTIRE SYSTEM HAS BEEN COMPLETELY INSTALLED, THE COOLING WATER DISTRIBUTION SYSTEM SHALL BE COMPLETELY CLEANED AND CHECKED FOR LEAKS. THE WATER TREATMENT CONTRACTOR SHALL ADD INITIAL CHEMICAL CLEANING AGENT TO FACILITATE FLUSHING AND TO PREVENT CORROSION DURING THE LEAK CHECK PROCESS. THE SYSTEM SHALL BE FREE OF ALL CUTTING OILS AND OTHER DEBRIS. THE WATER TREATMENT CONTRACTOR SHALL FILL THE COOLING SYSTEM WITH CLEAN, FRESH WATER AND THOROUGHLY CHECK SYSTEM PIPING FOR LEAKS. FOLLOWING THE LEAK CHECK, THE CLOSED SYSTEM SHALL BE FLUSHED UNTIL THE LEAVING WATER RUNS CLEAR. DURING THIS PROCESS, ONE OF THE HOSES AT EACH FAN COIL UNIT WILL BE CONNECTED TO BYPASS THE FAN COIL UNIT, FLOW STRAINER, AND FLOW CONTROL DEVICE. THE WATER TREATMENT CONTRACTOR SHALL ENSURE THAT SYSTEMS NOT BE LEFT DRY DURING SYSTEM DRAIN-DOWN.

2. COOLING WATER SYSTEM CHEMICAL TREATMENT:

   -FILL SYSTEM WITH A SOLUTION OF 10% BY WEIGHT OF A HEAVY DUTY ALKALINE LIQUID CLEANER. THE CLEANER SHALL BE CAPABLE OF WETTING AND PENETRATING HEAVY SOIL DEPOSITS OF OIL OR GREASE, AND OF KEEPING THESE PRODUCTS IN SUSPENSION.

   -CIRCULATE SOLUTION FOR A MINIMUM OF 8 HOURS, THEN FLUSH SYSTEM WITH CLEAN FRESH WATER UNTIL ALL SOLIDS HAVE BEEN CLEANED FROM THE SYSTEM. CLEAN ALL STRAINERS IN SYSTEM.

   -FOLLOWING CLEAN AND FLUSH PROCESS, RE-CONNECT THE AIR HANDLING UNIT HOSE KIT FOR NORMAL OPERATION AND INSPECT ALL FLOW CONTROL DEVICES AND STRAINERS. WHEN NECESSARY, THESE COMPONENTS SHALL BE FLUSHED TO ENSURE UNOBSTRUCTED FLOW TO THE AIR HANDLING UNIT.

   -THE WATER TREATMENT CONTRACTOR SHALL REFILL SYSTEM WITH A MIXTURE OF 70% VOLUME OF CLEAN WATER AND 30% VOLUME OF DOWFROST HD PROPYLENE GLYCOL WITH BUILT-IN CHEMICAL INHIBITOR.

3. AT THE CONCLUSION OF CLEANING AND TREATING, THE WATER TREATMENT CONTRACTOR SHALL CERTIFY IN WRITING THAT THE SYSTEM HAS BEEN CLEANED AND TREATED AS SPECIFIED.

4. AT THE END OF ONE YEAR, THE SYSTEM SHALL AGAIN BE CHECKED AND REFILLED AS REQUIRED TO MEET THE ABOVE SPECIFICATIONS. SERVICE DURING THE ONE-YEAR WARRANTY PERIOD SHALL BE AS REQUIRED TO MAINTAIN ABOVE SPECIFICATIONS.

3 COOLING WATER SYSTEM FLUSHING & TREATMENT

NOT TO SCALE

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REVISIONS

CONSULTANTS ◇

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CONSTRUCTION DOCUMENTS

PROJECT ◇
ITD # FM22011
IDAHO TRANSPORTATION DEPARTMENT
ITD DISTRICT 2
MATERIALS LAB REMODEL
2606 FRONTAGE RD, LEWISTON, ID 83501

DRAWING ◇
MECHANICAL
DETAILS

SHEET ◇
M4.6