1.1 Installation Material:

A. Input/Output Control Wiring and Pathways:

1. All cables (< 50 VAC/VDC) used within control system shall contain an overall jacket (plenum rated).

2. Jacket Color-Coding requirements:

a) I/O low voltage signal wire: Gray
b) Field Device Low Voltage (< 50 VAC/DC) Power Wiring: Orange

**** PROJECT NOTE, for the Consultant **** When working in an existing facility the existing (or dominant) color scheme should be followed.

3. Instrumentation I/O Conductors (<50 Volts and Under):

4. No wire smaller than #18 AWG shall be used unless using pre-manufactured cable.

5. Sizing of cable, conduit, j-boxes and raceways to accommodate system with 25% spare capacity. Minimum conduit size shall be ¾" at all locations. All wall mount devices shall be in conduit and routed to nearest accessible ceiling location. Stubouts shall be a minimum of 12" from wall line.

6. Low voltage control cable (<24 vac/vdc) and communication wiring concealed above accessible ceilings does not require EMT, however, cables run above accessible ceilings shall be run within a j-hook raceway system spaced no more than 4 ft apart. Cables run in concealed areas, exposed mechanical/electrical rooms or within un-accessible spaces shall be installed in EMT. Run pathways and cables parallel and perpendicular to building structure.

7. Flexible Metal Conduit shall be used for vibration isolation and but shall be limited to 3 feet in length when terminating to any device.

8. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Extra precautions shall be taken when pulling and shortening "vendor furnished" manufactured cables. When required, any extra length with respect to manufactured cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

9. No wire nuts in control panels, junction boxes or any enclosure. Wire nuts may be used only at field device termination points.

10. Avoid using equipment or field instrumentation enclosures as pass through junction boxes. Ensure device can be replaced without impacting other device wired connections.

B. Communication Cable:

1. BAS network communication cable shall not be spliced unless a terminal strip and enclosure is used.
2. No T-Tapping within the communication system except at designated controller termination points

C. Air Piping:

1. Copper Tubing:

a) Type L, hard or soft seamless, ASTM B88, wrought copper soldered fittings, ANSI B16.22 except at connections to apparatus, where brass compression-type fittings shall be used.

b) Solder joints shall be made with ASTM B32, 95-5 tin-antimony solder-joint, Bridgit or Silvabrite.

2. Plastic Tubing:

a) Fire resistant virgin polyethylene, meeting stress-crack test ASTM D1693-60T.

b) Individual tube polyethylene or multi-tube instrument tubing bundle shall be classified as flame retardant under UL 94 and polyethylene material shall be rated as self-extinguishing when tested in accordance with ASTM D 635.

c) All tubing installed outdoors shall be enclosed in EMT

**** PROJECT NOTE, for the Consultant **** Use only copper tubing for all outdoor environments and within unconditioned mechanical rooms.

3. Isolation valves for air piping to be threaded or soldered, two piece, bronze ball valves. Valves shall be suitable for intended service and pressure.

4. Conceal all piping, except for piping in mechanical rooms and other areas where mechanical system piping is exposed.

5. Install exposed piping and conduit parallel to or at right angles to building structure and support adequately at uniform intervals. Use only tool-made bends.

6. Polyethylene tubing not exceeding 18" may be used for final connection to instrument or actuator except in high temperature locations such as mechanical rooms with steam heat exchangers or areas exposed to outside environment. Use hard copper for these applications.

7. Install polyethylene tubing with no concealed splices and number code all tubing.

8. Make tests on sectional piping during progress of installation to ensure no leakage.

9. Piping type shall be as follows:

a) Inside Panels: Use polyethylene tubing.

b) Piping Serving Smoke Dampers and Combination Fire-Smoke Dampers: Use hard copper for mains and exposed piping and hard or soft copper for branches and concealed piping.

10. Exposed Spaces:

a) Use hard copper tubing or Polyethylene tubing may be used if run in fully enclosed EMT raceway where environment is within temperature limits of polyethylene tubing.

b) Use PVC coated copper tubing for wet environments.

11. Concealed:

a) Use hard copper, soft copper or polyethylene tubing.

12. Concrete Buried:

a) Use hard copper, soft copper or polyethylene tubing in metal or plastic conduit.

**** PROJECT NOTE, for the Consultant ****Mounting control panels out in the open weather should be avoided whenever possible. In the event panels must be installed outdoors then adequate protection is imperative. Protection shall include water tightness and additional cooling/ventilation to ensure the internal electronics do not exceed their rated temperature/humidity limits.

D. Local Control Panels

1. Local control panels shall be constructed of steel, high strength composite, or extruded aluminum with hinged door and keyed lock, with manufacturer's standard color. Construction shall comply with NEMA 1 standards for interior panels, NEMA 4 for wet environments and panels mounted outside. Keyed cabinets not required in rooms that are secured.

2. Panel mounted controlling instruments, temperature indicators, relays, and switches shall be factory installed and permanently labeled. Devices shall be located inside or flush mounted on face of panel. All gauges shall be mounted in panel face or in separate panel.

3. Panel size shall be such that the mounted back panel can support the intended controller/auxiliary device space requirements while allocating no more than 60% filled area to allow for future additions and modifications.

4. Control panels and operator's terminals serving equipment fed by standby power shall also be served by standby power system.

5. Provide local control panel for each system where more than one control device requires field mounting (air handling units, central exhaust systems, pumping systems, steam systems etc…). Single devices may be mounted exposed on piping or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served. Avoid mounting control panels on equipment.

6. Mount panel on wall with suitable brackets or on floor with self-supporting stand.

7. Mount top of panel no higher than 6 feet above finished floor.

8. Install panels so front cover door can swing full open without interference and maintain a minimum of 36" clearance.

9. Terminate all wire at terminal blocks inside enclosures.

1.2 Control Valves:

**** PROJECT NOTE, for the Consultant ****Consultant should ensure control diagrams and/or valve schedules clearly indicate fail position requirements. UF Standard is to have cooling devices/heating devices

fail to last position, and steam valves to fail closed. Terminal unit control valves should be configured to fail to last commanded position. The preferred chilled water control valve solution is the Belimo Energy Valve™.

A. Chilled water Energy Valve – Belimo Energy Valve™: The Energy Valve is an energy metering pressure independent control valve that measures, documents and optimizes water coil performance.

B. Provide 5-year warranty on valve/actuator (standard shall be Belimo)

C. Globe Style Control Valves (Steam Control Applications Only):

1. Valves shall be bronze or brass body, threaded, 150 psi rating for 2" and smaller, iron body bronze mounted, flanged, 125 psi rating for 2-1/2" and larger.

2. Valves shall have stainless steel stems, spring-loaded teflon packing, and replaceable seats and discs.

D. Characterized Ball Type Control Valves (Hot Water and Cooling Coil Applications up to 2")

1. Use 2 port ball valves (normally open or closed based on sequence of operation) or 3 port ball type valves as required by design.

2. Valves shall be bronze or brass body, 150 psi rating. Ball valves larger than 3" are not permitted.

3. Valves shall have stainless steel ball and stem, valve stem seals with dual EPDM O-Rings, rangeability must be greater than 150:1, and shall have equal percentage flow characteristics.

E. Butterfly Control Valves (Hot Water and Cooling Coil Applications 2 ½" and larger)

1. Modified equal percentage high performance butterfly valves shall be used for modulating applications. Disc shall be made of stainless steel.

2. General-purpose butterfly valves may be used for two-position control.

F. Water type control valves shall be sized with a pressure drop range of 3 – 6 psid [EOR to confirm and edit as necessary].

**** PROJECT NOTE, for the Consultant ****UF has standardized on the Belimo Energy Valve for all chilled water coil applications. This does not include small FCUs and Terminal Units.

1. Flow Meter and Temperature Sensors: A characterized control valve shall be integrated with an electronic (ultrasonic or electromagnetic) wet calibrated flow sensor (accuracy +/- 2%) providing analog flow feedback, and two temperature sensors providing feedback of coil inlet and outlet water temperatures. The valves shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psig (7 to 345 kPa). Software shall control the valve to avoid the coil differential temperature from falling below a programmed set point.

2. Coil Optimization: Software shall control the valve to avoid the coil differential temperature from falling below a programmed setpoint. Real-time data and configuration of valve operating parameters shall be available by means of BTL listed BACnet MS/TP. Monitored points shall include inlet and outlet coil water temperatures, absolute flow,

absolute valve position, absolute coil power and total heating/cooling energy in BTU/hr. Configuration points shall include valve, flow and power settings. Historical trend data shall be stored for up to 13 months and be retrievable in a standard time-stamped format.

1.3 Control Dampers

**** PROJECT NOTE, for the Consultant ****Consultant shall coordinate specs with regard to damper and actuators to avoid conflicts. Dampers are often specified with the equipment. Dampers shall be provided under mechanical contractor scope. Actuators shall be provided under control contractor scope.

A. Modulating control dampers shall be opposed blade or parallel blade type and two position (open/close) dampers shall be parallel blade type. Use parallel blades (angled appropriately) at mixing box to promote additional mixing.

B. All blade linkage hardware shall have corrosion-resistant finish (stainless steel) and be readily accessible for maintenance.

C. When using end switch proof of damper position to prevent equipment damage, external mercury type end switches shall be used in lieu of internal actuator micro switch for safety/run enable circuits of VFD/starters. End switches shall be accessible and viewable.

D. Standard Modulating and Two-Position Dampers:

**** PROJECT NOTE, for the Consultant ****UF FS requires a higher quality damper to ensure long term sustainable operation.

1. Acceptable Manufacturers:

   i Johnson Controls
   ii Ruskin
   iii Tamco
   iv Greenheck

2. Damper frame shall be aluminum or stainless steel and not be less than .125” in wall thickness. Frame shall be clear anodized to a minimum thickness of 0.7mil (18 microns) deep. Where screws are used, they must be 316 stainless steel.

3. Linkage hardware shall be aluminum and stainless steel, installed in the frame side, out of the airstream, and accessible after installation. All aluminum linkage hardware parts shall be clear anodized. All non-aluminum linkage hardware parts shall be 300 series stainless steel. Adjustable hexagon drive rod, U-bolt fastener and retaining nuts are to be 300 series stainless steel.

4. Axles: Minimum shall be stainless steel

5. All ball bearings on blade shafts shall be sealed

1.4 Damper and Valve Actuators:

A. All actuators shall carry a minimum 5 year warranty. Preferred manufacturer is Belimo.

B. Damper and valve actuators shall be electric type and include the following features.

**** PROJECT NOTE, for the Consultant ****Consultant should confirm pneumatic requirements with UF FS. In some cases, an existing pneumatic system may be extended to accommodate new work

1. Each actuator shall be full-proportioning or two-position type as required or specified, and shall be provided with a spring-return capability for fail open or fail closed position during power interruption as indicated and/or as required. Smoke dampers and steam valves serving pressure rated heat exchangers or convertors shall fail closed with mechanical spring.

2. Actuators shall be electric motor/gear drives which respond proportionally to analog voltage or current input. Stroke time shall be in accordance with project requirements. Stroke time for terminal equipment shall generally be compatible with its associated local controller, but typically no more than 2 minutes.

3. Provide spring return feature for fail open or closed positions as required by control sequence.

4. Provide integral end switches as required by control sequence.

5. Specific to Terminal Unit Actuators:

    a) Hot water/cold water terminal units - Utilize factory assembled ball valve with horizontal mount; non-spring return proportional actuator (2-10 Vdc or 4-20ma). Electric actuator installed on ball valves shall have a separate and distinct operating handle used to position the valve into any desired position once power is removed or a valve failure occurs.

**** PROJECT NOTE, for the Consultant ****Consultant shall ensure all actuated devices get cycled periodically. This may require specific sequences that force the control system to cycle dampers/actuators periodically to prevent long term seizure. In some cases the cycling may need to be some type of minimal movement over a limited range (i.e. 75% - 100%) when a 0% - 100% change of the device is not possible. This would include return control dampers within units designed to turn off at night.

1.5 Instrumentation:

A. Pressure Gauges:

1. Air pressure indicating gauges to be at least 1-1/2" diameter. Gauge faces to be marked with normal range of unit being controlled.

2. Pressure gauges used for panel-mounted indicators shall be marked in appropriate units and with appropriate range of values. Panel mounted indicators shall be minimum 4-1/2" in diameter and have accuracy of 1% of scale range.

B. Analog Electronic Instrument Indicators:

1. Electronic indicators, used for displaying sensor and/or output values as measured by current or voltage, shall be panel mount type and at least 2" square. Output shall be digital with 1/2" high LED or backlit LCD displays.

2. Electronic indicators shall be marked/programmed with appropriate units (Degrees, psi, %RH, gpm, cfm, etc.) and with appropriate range of values. Panel mounted indicators shall have minimum accuracy of 1% of scale range. Digital units shall be scaled to show 3 digits plus 1 decimal point.

C. Temperature Switches (Electric Non-digital Thermostats):

1. Line voltage or low voltage type suitable for application with adjustable setpoint and setpoint indication.

2. Thermostats with remote sensing bulb shall have liquid filled sensing element and exposed setpoint adjustment.

3. Wall mounted space thermostat enclosure shall have concealed sensing element and exposed setpoint adjustment.

4. Unless otherwise stated, space thermostat covers shall be factory standard cover.

D. Temperature Low Limit Switches (Freeze Stats):

1. Electric 2-position 4 wire, 2 circuit temperature sensing element with manual reset. Controls shall be capable of opening circuit if any one-foot length of sensing element is subject to temperature below established setpoint.

2. Sensing element shall not be less than one lineal foot per square foot of coil surface area. Unless otherwise indicated, calibrate temperature switch setpoint to 38°F.

3. Low Limit switches shall be hardwired into safety circuit of motor control device. Additional dry contact shall be used for BAS feedback.

4. Location of installed device – must be accessible from outside of unit, must be protected from the water and must be mounted no more than 60” AFF. Provide a single remote (hardwired) reset switch when conditions require device to be mounted above 60” AFF or when multiple devices are used.

5. Distribute sensing element across entire face of coil being protected (generally downstream of heating coil). Serpentine sensing element, starting at the lowest point (6” above coil bottom) of the coil being protected. Operation of low limit trip shall provide protection to all coils.

6. Provide multiple devices for large AHUs where required to ensure complete coverage.

7. Low limit trip activation shall cause all water coils to be overridden to full flow.

E. Relays (General Control Devices):

1. Equal to IDEC type or RIB series. Coil shall match control circuit characteristics. All relays shall include LED indication of status.

2. All equipment start/stop relays shall include an integral HOA function.

3. Provide DIN rail mountable (Snap type) mounting sockets when relays are mounted in control panel.

4. Provide RIB type relays for field control devices mounted on exterior of starter or VFD.

5. Mount relay for easy accessibility and for easy visual accessibility.

F. Position Switches (End Switches)

1. Dampers: Rotary end switches shall consist of switch mounted on a ½" damper crank arm (Similar to Kele & Associates TS-475).

2. It is not acceptable to use the actuator auxiliary proof for confirmation of open position when proof is used to protect equipment.

3. Door position switches shall be magnetic proximity type.

G. Current Switches (Current Relay):

1. Induction type sensor clamped over a single phase of AC electrical power conductor shall be solid-state sensor with adjustable threshold and normally open contacts. Each current switch shall be selected for proper operating range of current.

2. Current switch shall be adjusted to sense status at all normal operating ranges
3. Split core with LED status and local adjustment of trip point. Self-calibrating models are not permitted.

H. Wet Media Differential Pressure Transmitter:

1. Acceptable Manufacturers: Ashcroft, Setra, Veris

2. Pressure sensor and integral 4-20 mA VDC (or 2-10 Vdc) transmitter. Select instrument for intended usage (differential pressure, gauge pressure, level, etc.), range, maximum pressure/temperature. Sensor shall be capacitance or strain gauge type. Enclosure to be NEMA 4.

3. Differential pressure transmitters shall include 5-valve manifold for servicing and calibration.

4. Differential pressure sensing lines or 5 valve manifold shall include a dedicated test port on both the high and low side sensing lines for external calibration.

5. Sensor accuracy shall be capable of +/-1% FS combined linearity, hysteresis, and repeatability.

6. Provide local LCD display.

7. The transmitters shall be installed in an accessible location whenever possible and no higher than 60" above finished floor.

I. Wall Mounted Space Temperature Sensors (no local adjustable dial):

1. Sensors shall be platinum, nickel RTD type or thermistor, with the following minimum performance requirements:

a) Accuracy: ± 0.5F at 70°F (Class B)

2. Unless otherwise stated, space sensor covers shall be factory standard cover

3. Install space sensors where indicated, as required to perform specified controls, or

directed to meet job site conditions.

4. Mount all sensor types at the same height whenever possible.

5. Any room sensor mounted on exterior walls shall be mounted on thermally insulated sub-base.

6. Relocate room sensors if required due to draft, interferences with cabinets, writing board, etc., or improper sensing.

7. Room sensors in gymnasium, locker rooms and other areas exposed to possible damage shall be protected by heavy-duty cast and die formed guard.

8. Provide a minimum ¾" conduit from sensor box to above the ceiling where it shall stub out into an accessible area parallel with the ceiling.

J. Wall Mounted Room Thermostats (with local adjustable dial):

1. Setpoint ranges shall be resettable only from remote BAS. Temperature sensors shall be compatible with the associated controlled devices (e.g. DDC air terminal controller). Mounting box shall be recessed type unless otherwise indicated, or required by the building construction materials.

2. Thermostat shall incorporate a thermistor/RTD element and an integral portable operator terminal unit plug-in port for remote communication and testing.

3. Temporary override push-button shall be installed at all locations where required.

4. Use only warmer/cooler setpoint adjustment dial (no graduated scale). Minimum and maximum adjustable range shall be set through the BAS. Default shall be +/- 3°F.

5. In general room thermostat covers shall be factory standard cover.

6. Unless otherwise stated, room thermostat shall not include a local LCD display.

7. Install space thermostats where indicated, as required to perform specified controls, or directed to meet job site conditions.

8. Mount adjustable space thermostats 4 ft above floor to satisfy ADA.

9. Mount all sensor types at the same height whenever possible.

10. Any room thermostat mounted on exterior walls shall be mounted on thermally insulated sub-base.

11. Relocate room thermostats if required due to draft, interferences with cabinets, writing board, etc., or improper sensing.

12. Room thermostats in gymnasium, locker rooms and other areas exposed to possible damage shall be protected by heavy-duty cast and die formed guard.

13. Provide a minimum ¾" conduit from sensor box to above the ceiling where it shall stub out into an accessible area parallel with the ceiling.

K. Wet Insertion Temperature Sensors:

1. Nickel, thermistor or platinum RTD type, with the following minimum performance:

   a) Accuracy: +/- 0.1°F at 32°F

2. Wells mounted in pipe 3" and larger shall be installed in horizontal or vertical lines provided element is always in flow (for condensate and other gravity return lines, install in bottom of pipe).

3. Wells mounted in pipe 2-1/2" and smaller shall be installed at a 90° pipe junction consisting of tee fitting (2" minimum size) and appropriate reducing fittings. Install sensor well pointed upstream in tee.

4. Wells shall be stainless steel and include thermal grease to ensure adequate heat transfer.

L. Duct Mounted Averaging Temperature Sensors:

1. Use where temperatures are prone to stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required. All sensors located within the AHU compartment shall be averaging.

2. Serpentine sensor in duct to maximize coverage of measured area.

3. Duct mounted sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

4. Nickel, thermistor or platinum RTD type, with the following minimum performance.

   a) Accuracy: ± 1.0°F at 70°F

5. Provide non-metal support system to ensure correct minimum bend radius.

6. Provide isolation where sensor comes into contact with dissimilar metal.

7. Rigid averaging temperature probes are not allowed.

M. Space Humidity Sensors/Transmitters:

1. Space humidity sensors shall be wall mount type with cover to match room thermostats and/or temperature sensors.

2. Use combination temperature/humidity sensors whenever possible. Both temperature and humidity accuracy requirements shall still apply when using the combination type sensor

3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.

   a) Accuracy: ±2% RH at 77°F range 12% to 80% RH

4. Space humidity sensor covers shall be factory standard cover unless otherwise stated.

N. Duct Mounted Single Point Temperature Sensors:

1. Nickel or platinum RTD type, with the following minimum performance:

   a) Accuracy: +/- 0.5°F at 70°F

O. Duct Mounted Humidity Sensors/Transmitters:

1. Duct humidity sensors shall be accessible.

2. Use combination temperature/humidity sensors whenever possible. Both temperature and humidity accuracy requirements shall still apply when using the combination type sensor.

3. Sensing element shall be resistive bulk polymer, or thin film capacitive type. Sensor/transmitter shall have the following minimum performance.

   a) Accuracy: ± 2% RH at 77°F over 20% to 80% RH

P. Air Flow Sensors/Transmitters:

**** PROJECT NOTE, for the Consultant **** Consultant should verify application and use this technology where operating ranges fall within acceptable velocity limits.

1. Manufacturers: Ebtron Gold Series or Air Monitor with the following characteristics:

2. Velocity measured by each sensor shall be linearized, summed, averaged, and converted to 4-20 mA output (or 2-10Vdc) signal proportional to air flow rate (CFM) by transmitter electronics.

3. Shall include NIST traceable calibration certificate

4. Measured value converted to airflow (CFM) shall have accuracy within 2% rate ± 0.1% full scale throughout velocity range and temperature and humidity change of 40 to 130°F, and 10-95% RH (non-condensing).

5. Manufacturer shall provide all cabling required to connect probe assemblies and transmitter electronics. Transmitter and/or systems, which require periodic calibration to maintain accuracy specified shall not be acceptable.

6. Provide a local display to indicate calculated cfm. Display shall be remotely mounted at no higher than 60 inches above finished floor.

Q. Differential Pressure Transmitters (Filter and duct static applications):

1. Provide transducers/transmitters to convert differential pressure into electronic signal.

2. Unit shall be capable of transmitting linear 4 to 20 mA DC (or 2-10Vdc) output signal proportional to the differential pressure input signals with the following minimum performance and application criteria:

   a) Span: Depends on application
   b) Accuracy: ± 1.0% of full scale
   c) Response: Less than 1 second for full span input

3. Exhaust air system static pressure transducers/transmitters shall be furnished with protective integral HEPA air filters on sensing lines within 12 inches of dust penetration

when installed in hazardous exhaust duct.

4. Provide local LCD display.

5. Provide test ports for external connection and calibration

6. Mount all transducers in associated control panels.

7. Terminate transducers directly to the controller that is implementing control loop. Using remote controllers and software data sharing is not allowed.

R. Building and Space Pressure Differential Transmitter:

1. Manufacturers: Setra, Veris, TSI

   a) Accuracy: ± 1.5% full scale, 0.5% reading
   b) Repeatability: ± 0.2% of full scale

2. Provide local LCD display.

3. Use outdoor air static pressure pickup port similar to Dwyer A420 when measuring building static.

S. Carbon Dioxide Sensor: (Space or Duct Mounted)

1. Manufacturer: Veris CXD, Vaisala, General Electric

2. Provide non-Dispersive Infra-Red (NDIR) carbon dioxide sensor suitable for room mounting.

   a) Range 0-2000 PPM
   b) Accuracy Accuracy ±30 ppm ±2% of measured value
   c) Calibration frequency No less than every 5 years

3. CO2 sensors shall carry a minimum 5 year warranty. Preferred manufacturer is Veris.

1.6 Energy Metering:

A. General: All sensors /transducers shall be appropriately selected to most closely match the expected sensing range. If, upon startup and balancing, a sensor/transducer is operating below 20% or above 80% of its sensing range, the sensor/transducer shall be replaced at no additional cost with an appropriate range such that the measured value (operating at normal conditions) is between 30% and 70% of the sensor/transducer range.

1. Btu Energy Meter (Chilled water and Heating Hot Water):

   a) The entire energy metering system shall be built and calibrated by a single manufacturer, ONICON Incorporated or Flexim, and shall consist of a flow meter, two matched temperature sensors, a Btu (tonnage) [chilled water/hot water] calculator, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST* traceable calibration shall be provided with each system and shall cover the flow meter and temperature sensors. All equipment shall be covered by a manufacturer's two year warranty.

b) Btu Meter: Provide a Btu Meter calculator. The Btu meter shall provide the following points both at the integral LCD and as outputs to the building control system: Energy Total [ktonhr or MBtu], Energy Rate [tons or Btu/hr], Flow Rate (GPM), Flow Total (KGal) Supply Temperature (DEGF) and Return Temperature (DEGF). Output signals shall be serial network protocol conforming to [BACnet® MS/TP, BACnet/IP]. Each Btu meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).

c) Temperature sensors: Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application. The calculated differential temperature used by the BTU meter calculation shall be accurate to within ±0.15 (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).

2. Flow Meter: Refer to the following flow meter sections for specific flow meter requirements. The flow meter shall be installed either in the supply or return pipe of the system to be measured following the manufacturer's instructions with particular attention to upstream and downstream straight pipe runs.

a) The basis of design shall be electromagnetic flow (Onicon) or ultrasonic flow (Flexim) meter complete with integral converter.

b) The flow meter size shall be selected based on the minimum and maximum flow range for the application.

c) Inline flow tube style flow meters shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene for low temperature service, PFTE for hot water service.

d) Each flow meter shall be individually wet-calibrated and accurate to within ±0.2% of reading. A certificate of calibration shall be provided with each flow meter.

e) All flow meters shall be capable of measuring bi-directional flow.

f) Each flow meter shall be factory programmed for its specific application, and shall be reprogrammable using the integral keypad on the converter (no special interface device or computer required).

3. Steam Flow Meter

a) Furnish and install an Onicon F-2000 Series Vortex Mass Flow Meter complete with integral density compensation to provide direct mass steam flow output. The flow meter shall calculate mass flow corrected for density with real time calculations based on temperature measured by an integral 1temperature sensor.

b) The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer's recommendations. Provide a flow straightener, if required to meet the manufacturer's minimum upstream and downstream straight pipe run requirement. Provide lateral and horizontal supports as required to minimize vibration at the meter location.

c) Each flow meter shall be individually calibrated at five points from 0-250 ft/s against the manufacturer's flow standards. The manufacturer shall provide a certificate of

calibration for each meter.

d) The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

e) Mass flow accuracy shall be within ±1.5% of actual reading over the range of the meter, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation.

f) The meter shall be provided with ANSI class 150 or class 300 flanges as required to meet system requirements. The maximum operating temperature shall be 460 F.

g) The flow meter body shall be constructed of 300 series stainless steel and include a weather-tight NEMA-4 aluminum electronics enclosure.

h) The meter shall display steam mass flow rate and mass flow total with an integral LCD display and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.

i) The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the BAS. All outputs shall be linear with mass flow rate.

j) Remote Serial Network Interface Module: Provide an ONICON D-100 Network Interface. The network interface shall transmit Mass Flow Rate [lb/hr] and Total Mass data [Klbs] via a serial network conforming to one of the following protocols: [BACnet MS/TP, BACnet IP]

4. Natural Gas Meter

a) Furnish and install an F-5100 Series Thermal Mass Flow Meter complete with integral density compensation to provide direct mass flow output. The flow meter shall calculate mass flow rate (Cfh) and mass flow consumption (therms) directly and shall not require additional pressure or temperature compensation.

b) The flow meter shall be sized by the manufacturer for each specific application and installed according to manufacturer's recommendations. Provide lateral and horizontal supports as required to minimize vibration at the meter location.

c) Each flow meter shall be individually calibrated at five points against the manufacturer's flow standards. The manufacturer shall provide a certificate of calibration for each meter.

d) The flow meter shall be programmed by the manufacturer for each specific application and shall be ready to use upon delivery.

e) Mass flow accuracy shall be within ±2.0% of actual reading over the range of the meter, including all errors associated with velocity measurement, temperature and/or pressure measurement, and density compensation.

f) The meter shall be provided with wetted metal components 316 stainless steel.as required to meet system requirements. The maximum operating temperature shall be 200 F.

g) The flow meter body shall be constructed of 300 series stainless steel and include a weather-tight NEMA-4 aluminum electronics enclosure.

h) The meter shall display mass flow rate with an integral LCD display and support field programming of all parameters. The meter shall also have integral diagnostics to verify installation conditions and the proper operation of the meter.

i) The meter shall provide a loop-powered 4-20 mA output signal calibrated in direct mass flow rate units for connection to the BAS. All outputs shall be linear with mass flow rate.

j) Remote Serial Network Interface Module: Provide an ONICON D-100 Network Interface. The network interface shall transmit Mass Flow Rate [Cfh] and Total Mass data [therms] via a serial network conforming to one of the following protocols: [BACnet MS/TP, BACnet IP].

5. Electrical Power Meter:

**** PROJECT NOTE, for the Consultant ****It is preferred that the BAS vendor be responsible for providing and installing all electric submeters. It is important that the electric energy meters be shown on both the electrical plan riser (for location) and on the control sheets (IC sheets). Electric meters need to be specified under Division 25.

a) Manufacture: Veris Industries or Siemens DEM

b) Systems Accuracy ±1% of reading from 2% to 100% of the rated current of the CTs. accomplished by matching the CTs with a meter and calibrating them as a system.

c) Shall cover and service where the phase A-N voltage is ≤300VAC and the phase-to-phase voltage is≤480VAC nominal with neutral.

d) In each instance, provide separate C.T. for each phase of system to be metered. C.T.s shall be designed for switchboard and panelboard mounting except where specifically indicated otherwise. Select turns ratio to coordinate with size of system being metered. Properly label each C.T. to clearly show turns ratio on basis of primary winding to secondary winding currents. CTs shall be insulated to full voltage rating of panel

e) Frequency 50/60Hz.

f) Protection Class NEMA 1

g) BACnet MS/TP communication card: provide as necessary for each meter requiring current input into BAS.

END OF SECTION