

Haywood Community College  
Creative Arts Building  
Solar Development Package  
Addenda #1- May 27, 2010

**Innovative Design**

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Raleigh, NC 27603  
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Questions from solar developers:

1. Provide the 8760-hour heating and cooling load estimates from e-quest.  
Innovative Design (ID): See attached excel document: HCC Hourly HC.
2. Provide specification for piping insulation.  
ID: See attached specification section: 22-07-19 Plumbing Piping Insulation.
3. Provide schedule for pumps.  
ID: See attached document Haywood - Pump Schedule for electric and mechanical pumps. Note that schedules include pumps for entire building project, and the pumps in the scope of the solar development project are noted in the solar development drawing package.

Also Provided:

1. Specification Section 23-09-00 Building Automation System.

**SECTION 22-07-19**  
**PLUMBING PIPING INSULATION**

**PART 1 - GENERAL**

**1.01 SUMMARY**

- A. Section includes insulating the following plumbing piping services:
  - 1. Domestic cold-water piping.
  - 2. Domestic hot-water piping.
  - 3. Domestic recirculating hot-water piping.

**1.02 SUBMITTALS**

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. LEED Submittals:
  - 1. Product Data for Credit EQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
  - 2. Laboratory Test Reports for Credit EQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - 2. Detail attachment and covering of heat tracing inside insulation.
  - 3. Detail insulation application at pipe expansion joints for each type of insulation.
  - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
  - 6. Detail application of field-applied jackets.
  - 7. Detail application at linkages of control devices.
- D. Qualification Data: For qualified Installer.
- E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- F. Field quality-control reports.

**1.03 QUALITY ASSURANCE**

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. When fire-performance characteristics are important requirements, verify surface-burning characteristics of insulation materials by an independent testing agency and require test report submittals.
- C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- D. Comply with the following applicable standards and other requirements specified for miscellaneous components:
1. Supply and Drain Protective Shielding Guards: ICC A117.1.

#### **1.04 DELIVERY, STORAGE, AND HANDLING**

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

#### **1.05 COORDINATION**

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

#### **1.06 SCHEDULING**

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

### **PART 2 - PRODUCTS**

#### **2.01 INSULATION MATERIALS**

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Aeroflex USA, Inc.; Aerocel.
    - b. Armacell LLC; AP Armaflex.
    - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- G. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Johns Manville; Micro-Lok.
    - b. Knauf Insulation; 1000-Degree Pipe Insulation.
    - c. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

## **2.2 ADHESIVES**

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Aeroflex USA, Inc.; Aero seal.
    - b. Armacell LLC; Armaflex 520 Adhesive.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
    - d. K-Flex USA; R-373 Contact Adhesive.
  2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  1. Products: Subject to compliance with requirements, provide one of the following:
    - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    - b. Eagle Bridges - Marathon Industries; 225.
    - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    - d. Mon-Eco Industries, Inc.; 22-25.
  2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Use adhesive that complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

## **PART 3 - EXECUTION**

### **3.01 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
  1. Verify that systems to be insulated have been tested and are free of defects.
  2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### **3.02 PREPARATION**

- A. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### **3.03 GENERAL INSTALLATION REQUIREMENTS**

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  1. Install insulation continuously through hangers and around anchor attachments.
  2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
  4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
  1. Draw jacket tight and smooth.
  2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
  3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
    - a. For below-ambient services, apply vapor-barrier mastic over staples.
  4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
  5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
  - 1. Vibration-control devices.
  - 2. Testing agency labels and stamps.
  - 3. Nameplates and data plates.
  - 4. Cleanouts.

### **3.04 PENETRATIONS**

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
  - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
  - 1. Seal penetrations with flashing sealant.
  - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
  - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
  - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
  - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
  - 1. Pipe: Install insulation continuously through floor penetrations.
  - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

### **3.05 GENERAL PIPE INSULATION INSTALLATION**

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

- B. Where pipe expansion is anticipated, detail expansion compensation for insulation on Drawings and indicate intervals for its occurrence. See the Midwest Insulation Contractors Association's "National Commercial & Industrial Insulation Standards," Plate No. 41A.
- C. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
  2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
  3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
  4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
  5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
  6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
  7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
  8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
  9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- D. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- E. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
  2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
  3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

### **3.06 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION**

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
  1. Install pipe insulation to outer diameter of pipe flange.
  2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
  4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
  1. Install mitered sections of pipe insulation.
  2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
  1. Install preformed valve covers manufactured of same material as pipe insulation when available.
  2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  3. Install insulation to flanges as specified for flange insulation application.
  4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

### **3.07 INSTALLATION OF MINERAL-FIBER INSULATION**

- A. Insulation Installation on Straight Pipes and Tubes:
  1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
  4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
  1. Install preformed pipe insulation to outer diameter of pipe flange.
  2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.



3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
  4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
  2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install preformed sections of same material as straight segments of pipe insulation when available.
  2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
  3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  4. Install insulation to flanges as specified for flange insulation application.

### **3.08 FINISHES**

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

### **3.09 FIELD QUALITY CONTROL**

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Retain first paragraph below to require Contractor to perform tests and inspections.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

### **3.2 PIPING INSULATION SCHEDULE, GENERAL**

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
  1. Drainage piping located in crawl spaces.
  2. Underground piping.
  3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

### **3.3 INDOOR PIPING INSULATION SCHEDULE**

- A. Domestic Cold Water:
  1. NPS 1 (DN 25) and Smaller: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) thick..
  2. NPS 1-1/4 (DN 32) and Larger: Insulation shall be the following:
- B. Domestic Hot and Recirculated Hot Water:
  1. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be the following:

- a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- 2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be the following:
  - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- C. Floor Drains, Traps, and Sanitary Drain Piping within Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Flexible Elastomeric: 1 inch (25 mm) thick.

### **3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE**

- A. Domestic Water Piping:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 2 inches (50 mm) thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
- B. Domestic Hot and Recirculated Hot Water:
  - 1. All Pipe Sizes: Insulation shall be one of the following:
    - a. Flexible Elastomeric: 2 inches (50 mm) thick.
    - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
- C. Sanitary Waste Piping Where Heat Tracing Is Installed:
  - 1. All Pipe Sizes: Insulation shall be the following:
    - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

**END OF SECTION**

**SECTION 23-09-00**  
**BUILDING AUTOMATION SYSTEM**

**PART 1 – GENERAL**

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**1.01 RELATED DOCUMENTS**

- A. All work of this Division shall be coordinated and provided by the single Building Automation System (BAS) Contractor.
- B. The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades.
- C. The work of this Division shall be as required by these Specifications.
- D. If the BAS Contractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

**1.02 DEFINITIONS**

- A. Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.
- B. Binary: A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level.

- C. Building Automation System (BAS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, shall be provided by this Division BAS Contractor and to be interfaced to the associated work of other related trades.
- D. BAS Contractor: The single Contractor to provide the work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BAS work.
- E. Control Sequence: A BAS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.
- F. Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BAS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
- G. BAS Network: The total digital on-line real-time interconnected configuration of BAS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.
- H. Node: A digitally programmable entity existing on the BAS network.
- I. BAS Integration: The complete functional and operational interconnection and interfacing of all BAS work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BAS as required by this Division.
- J. Green Building: A building certified under the provisions of the United States Green Building Council's Leadership in Energy and Environmental Design program. Appropriate levels are Certified, Silver, Gold, and Platinum.
- K. Provide: The term "Provide" and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.
- L. PC: Personal Computer from a recognized major manufacturer, performance as specified.
- M. Furnish: The term "Furnish" and its derivatives when used in this Division shall mean supply at the BAS Contractor's cost to the designated third party trade contractor for installation. BAS Contractor shall connect furnished items to the BAS, calibrate, test, commission, warrant and document.
- N. Wiring: The term "Wiring" and its derivatives when used in this Division shall mean provide the BAS wiring and terminations.
- O. Install: The term "Install" and its derivatives when used in this Division shall mean receive at the jobsite and mount.
- P. Protocol: The term "protocol" and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BAS network nodes.
- Q. Software: The term "software" and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BAS industry for real-time, on-line, integrated BAS configurations.
- R. The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.
- S. Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.
- T. The following abbreviations and acronyms may be used in describing the work of this Division:
 

ADC	-	Analog to Digital Converter
AI	-	Analog Input

AN	-	Application Node
ANSI	-	American National Standards Institute
AO	-	Analog Output
ASCII	-	American Standard Code for Information Interchange
ASHRAE	-	American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG	-	American Wire Gauge
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
DAC	-	Digital to Analog Converter
DDC	-	Direct Digital Control
DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electrically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
GUI	-	Graphical User Interface
HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/Output
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
LEED	-	Leadership in Energy and Environmental Design
MCC	-	Motor Control Center
NC	-	Normally Closed
NIC	-	Not In Contract
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw

SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
USGBC	-	United States Green Building Council
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume
VDC	-	Volts, Direct Current
WAN	-	Wide Area Network

### 1.03 BAS DESCRIPTION

- A. The Building Automation System (BAS) shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BAS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
- B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BAS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.
- C. Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft SQL Server Express or Microsoft SQL Server as dictated elsewhere in this specification.
- D. The work of the single BAS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
- E. The BAS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BAS.
- F. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.
- G. Manage and coordinate the BAS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.
- H. The BAS as provided shall incorporate, at minimum, the following integrated features, functions and services:
  - 1. Operator information, alarm management and control functions.
  - 2. Enterprise-level information and control access.

3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.
4. Diagnostic monitoring and reporting of BAS function.
5. Offsite monitoring and management access
6. Monitoring and Reporting for LEED Green Building Certification
7. Energy management
8. Standard applications for terminal HVAC systems
9. Indoor Air Quality monitoring and control

#### **1.04 QUALITY ASSURANCE**

##### **A. General**

1. The Building Automation System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Automation Systems.
2. The BAS Contractor shall be a recognized national manufacturer, installer and service provider of BAS.
3. The BAS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.
4. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BAS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.
5. The Building Automation System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Automation Systems, and shall be the manufacturer's latest standard of design at the time of bid.
6. The BAS contractor will ensure all BACnet points are exposed.
7. All software licenses shall be turned over to the owner.
8. Any software program tools for field devices shall be provided to the owner.

##### **B. Workplace Safety and Hazardous Materials**

1. Provide a safety program in compliance with the Contract Documents.
2. The BAS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
3. The Contractor and its employees and subtrades comply with federal, state and local safety regulations.
4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.
5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.

7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.
9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

C. Quality Management Program

1. Designate a competent and experienced employee to provide BAS Project Management. The designated Project Manger shall be empowered to make technical, scheduling and related decisions on behalf of the BAS Contractor. At minimum, the Project Manager shall:
  - a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
  - b. Manage the financial aspects of the BAS Contract.
  - c. Coordinate as necessary with other trades.
  - d. Be responsible for the work and actions of the BAS workforce on site.

**1.05 REFERENCES**

A. All work shall conform to the following Codes and Standards, as applicable:

1. National Fire Protection Association (NFPA) Standards.
2. National Electric Code (NEC) and applicable local Electric Code.
3. Underwriters Laboratories (UL) listing and labels.
4. UL 864 UUKL Smoke Control
5. UL 268 Smoke Detectors.
6. UL 916 Energy Management
7. NFPA 70 - National Electrical Code.
8. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.
9. NFPA 92A and 92B Smoke Purge/Control Equipment.
10. Factory Mutual (FM).
11. American National Standards Institute (ANSI).
12. National Electric Manufacturer's Association (NEMA).
13. American Society of Mechanical Engineers (ASME).
14. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
  - a. Standard 62.1-2007 Standard for Indoor Air Quality
  - b. Standard 90.1-2007 Energy Standard for Buildings
15. Air Movement and Control Association (AMCA).
16. Institute of Electrical and Electronic Engineers (IEEE).
17. US-Environmental Protection Agency Energy Star Equipment Certification
18. American Standard Code for Information Interchange (ASCII)
19. Electronics Industries Association (EIA).



20. Occupational Safety and Health Administration (OSHA).
21. American Society for Testing and Materials (ASTM).
22. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.
23. Americans Disability Act (ADA)
24. ANSI/EIA 909.1-A-1999 (LonWorks)
24. ANSI/ASHRAE Standard 195-2004 (BACnet)

- B. In the case of conflicts or discrepancies, the more stringent regulation shall apply.
- C. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

## **1.06 SUBMITTALS**

### **A. Shop Drawings, Product Data, and Samples**

1. The BAS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.
2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.
3. Allow 15 working days for the review of each package by the Architect and Engineer in the scheduling of the total BAS work.
4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BAS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.
5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.
6. The BAS Contractor shall correct any errors or omissions noted in the first review.
7. At a minimum, submit the following:
  - a. BAS network architecture diagrams including all nodes and interconnections.
  - b. Systems schematics, sequences and flow diagrams.
  - c. Points schedule for each point in the BAS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.
  - d. Samples of Graphic Display screen types and associated menus.
  - e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.
  - f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.
  - ~~g.~~ Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.
  - ~~h.~~ Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address
  - i. All information required for USGBC LEED Green Buildings Certification pre-evaluation including applications and equipment impact on individual attainment of points. Where a specific device may assist in qualification for LEED points indicate and summarize contribution.

- j. Details of all BAS interfaces and connections to the work of other trades.
- k. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

## **1.07 RECORD DOCUMENTATION**

### **A. Operation and Maintenance Manuals**

1. Six (6) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BAS provided:
  - a. Table of contents.
  - b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
  - c. Manufacturers product data sheets or catalog pages for all products including software.
  - d. System Operator's manuals including all information required to maintain LEED Green Building certification.
  - e. Archive copy of all site-specific databases and sequences.
  - f. BAS network diagrams.
  - g. Interfaces to all third-party products and work by other trades.
2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

B. On-Line documentation: After completion of all tests and adjustments the contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server

## **1.08 WARRANTY**

### **A. Standard Material and Labor Warranty:**

1. Provide a one-year labor and three-year material warranty on the BAS.
2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BAS Contractor at the cost of the BAS Contractor.
3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BAS Contractor's normal business hours.

## **PART 2 – PRODUCTS**

### **2.01 GENERAL DESCRIPTION**

- A. The Building Automation System (BAS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BAS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.
- B. The Building Automation System shall consist of the following:
1. Standalone Network Automation Engine(s)

2. Field Equipment Controller(s)
  3. Input/Output Module(s)
  4. Local Display Device(s)
  5. Portable Operator's Terminal(s)
  6. Distributed User Interface(s)
  7. Network processing, data storage and communications equipment
  7. Other components required for a complete and working BAS
- C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.
- D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
  2. The System shall maintain all settings and overrides through a system reboot.
- E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.
- F. Acceptable Manufacturers
- 1) Johnson Controls, Metasys (Johnson Controls Branch Office only)
  - 2) Automated Logic, Harris Sales
  - 3) Siemens Building Systems, APOGEE (Control Management)

## **2.02 BAS ARCHITECTURE**

- A. Automation Network
1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.
  2. The BAS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.
  3. The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.
  4. Network Automation Engines (NAE) shall reside on the automation network.
  5. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
- B. Control Network
1. Network Automation Engines (NAE) shall provide supervisory control over the control network and shall support the following (2) communication protocols:
    - a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9
      - ◇ The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
      - ◇ The NAE shall be tested and certified as a BACnet Building Controller (B-BC).
    - b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).

2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.
3. DDC Controllers shall reside on the control network.
4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.
5. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

## 2.03 USER INTERFACE

### A. Dedicated Web Based User Interface

1. Where indicated on plans the BAS Contractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BAS Network Automation Engines to facilitate greater fault tolerance and reliability.
2. Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BAS Contractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.
  - a. Microsoft Internet Explorer for user interface functions
  - b. Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions
  - c. Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports
  - d. Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries
3. PC Hardware – The personal computer(s) shall be configured as follows:
  - a. The computer shall be Energy Star qualified
  - b. Memory – 1 GB Minimum
  - c. CPU– Intel Core Duo 2. 2.93 Hz Clock Minimum Speed ,
  - d. Hard Drive – 80 GB free hard drive space (40GB minimum)
  - e. Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department
  - f. CD ROM Drive – 32X performance
  - g. Ports – (2) Serial and (1) parallel, (2) USB ports
  - h. Keyboard – 101 Keyboard and 2 Button Mouse
  - i. CRT configuration – 1-2 CRTs as follows:
    - ◇ Each Display – 17" Flat Panel Monitor 1280 x 1024 resolution minimum, unit shall be Energy Star qualified
    - ◇ 16 bit or higher color resolution
    - ◇ Display card with multiple monitor support
  - j. LAN communications – Ethernet communications board; 3Comm or equal
4. Operating System Software

- a. Windows 7
- b. Where user interface is not provided via browser, provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.
- c. Provide software registration cards to the Owner for all included software.

B. Distributed Web Based User Interface

1. All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.
2. The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser supporting the following functions:
  - ◇ Configuration
  - ◇ Commissioning
  - ◇ Data Archiving
  - ◇ Monitoring
  - ◇ Commanding
  - ◇ System Diagnostics
3. Minimum hardware requirements:
  - ◇ 512 MB RAM
  - ◇ 2.0 GHz Clock Speed Pentium 4 Microprocessor
  - ◇ 100.0 GB Hard Drive.
  - ◇ 1 Keyboard with 83 keys (minimum).
  - ◇ SVGA 1024x768 resolution display with 64K colors and 16 bit color depth
  - ◇ Mouse or other pointing device

C. User Interface Application Components

1. Operator Interface
  - a. An integrated browser based client application shall be used as the user operator interface program.
  - b. The System shall employ an event-driven rather than a device polling methodology to dynamically capture and present new data to the user.
  - c. All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.
  - d. The user interface software shall provide help menus and instructions for each operation and/or application.
  - e. The system shall support customization of the UI configuration and a home page display for each operator.
- f. The system shall support user preferences in the following screen presentations:
  - ◇ Alarm
  - ◇ Trend

- ◇ Display
  - ◇ Applications
  - g. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.
  - h. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
    - ◇ User access for selective information retrieval and control command execution
    - ◇ Monitoring and reporting
    - ◇ Alarm, non-normal, and return to normal condition annunciation
    - ◇ Selective operator override and other control actions
    - ◇ Information archiving, manipulation, formatting, display and reporting
    - ◇ BAS internal performance supervision and diagnostics
    - ◇ On-line access to user HELP menus
    - ◇ On-line access to current BAS as-built records and documentation
    - ◇ Means for the controlled re-programming, re-configuration of BAS operation and for the manipulation of BAS database information in compliance with the prevailing codes, approvals and regulations for individual BAS applications
  - i. The system shall support a list of application programs configured by the users that are called up by the following means:
    - ◇ The Tools Menu
    - ◇ Hyperlinks within the graphics displays
    - ◇ Key sequences
  - j. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.
2. Navigation Trees
- a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.
  - b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.
  - c. The navigation trees shall be “dockable” to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.
3. Alarms
- a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:

- ◇ Log date and time of alarm occurrence.
  - ◇ Generate a “Pop-Up” window, with audible alarm, informing a user that an alarm has been received.
  - ◇ Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.
  - ◇ Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.
  - ◇ Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.
  - ◇ Any attribute of any object in the system may be designated to report an alarm.
- b. The BAS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.
  - c. The BAS shall allow a minimum of 4 categories of alarm sounds customizable through user defined wav.files.
  - d. The BAS shall annunciate application alarms at minimum, as required by Part 3.
4. Reports and Summaries
- a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:
    - ◇ All points in the BAS
    - ◇ All points in each BAS application
    - ◇ All points in a specific controller
    - ◇ All points in a user-defined group of points
    - ◇ All points currently in alarm
    - ◇ All points locked out
    - ◇ All BAS schedules
    - ◇ All user defined and adjustable variables, schedules, interlocks and the like.
  - b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.
  - c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.
  - d. The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.
  - e. Reports required for LEED Green Building Certification will be provided as part of this contract
5. Schedules
- a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
    - ◇ Weekly schedules

- ◇ Exception Schedules
    - ◇ Monthly calendars
  - b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
  - c. It shall be possible to define one or more exception schedules for each schedule including references to calendars
  - d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.
  - e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.
  - f. Schedules and Calendars shall comply with ASHRAE SP135/2006 BACnet Standard.
  - g. Schedules shall be optimized for energy efficiency in conjunction with LEED Green Building certification strategy.
  - h. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.
6. Password
- a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.
  - b. Each user shall have the following: a user name (accept 24 characters minimum), a password (accept 12 characters minimum), and access levels.
  - c. The system shall allow each user to change his or her password at will.
  - d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
  - e. A minimum of five levels of access shall be supported individually or in any combination as follows:
    - ◇ Level 1 = View Data
    - ◇ Level 2 = Command
    - ◇ Level 3 = Operator Overrides
    - ◇ Level 4 = Database Modification
    - ◇ Level 5 = Database Configuration
    - ◇ Level 6 = All privileges, including Password Add/Modify
  - f. A minimum of 100 unique passwords shall be supported.
  - g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
  - h. Operators will be trained in LEED Green Building energy management and sustainability concepts prior to receiving access to Operator Override or Database Modification levels.
  - i. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or



history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

7. Screen Manager
  - a. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.
8. Dynamic Color Graphics
  - a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.
  - b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.

The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.
  - c. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:
    - ◇ All graphics shall be fully scalable
    - ◇ The graphics shall support a maintained aspect ratio.
    - ◇ Multiple fonts shall be supported.
    - ◇ Unique background shall be assignable on a per graphic basis.
    - ◇ The color of all animations and values on displays shall indicate if the status of the object attribute.
  - d. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device
  - e. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.
    - ◇ The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.
    - ◇ In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.
  - f. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.
9. Historical trending and data collection
  - a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:
    - ◇ Any point, physical or calculated, may be designated for trending. Three methods of collection shall be allowed:
      - Defined time interval
      - Upon a change of value

- ◇ Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.
    - ◇ Trend data required for LEED Green Building certification will be configured in conjunction with applicable plans for energy reduction.
  - b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.
- 10. Trend data viewing and analysis
  - a. Provide a trend viewing utility that shall have access to all database points.
  - b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.
  - c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends
  - d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.
  - e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.
  - f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.
  - g. Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.
  - h. The Display shall support the user's ability to change colors, sample sizes, and types of markers.
- 11. Database Management
  - a. Where a separate SQL database is utilized for information storage the System shall provide a Database Manager that separates the database monitoring and managing functions by supporting two separate windows.
  - b. Database secure access shall be accomplished using standard SQL authentication including the ability to access data for use outside of the Building Automation application.
  - c. The database managing function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
    - ◇ Backup
    - ◇ Purge
    - ◇ Restore
  - d. The Database Manager shall support four tabs:
    - ◇ Statistics – shall display Database Server information and Trend, Alarm (Event), and Audit information on the Metasys Databases.
    - ◇ Maintenance – shall provide an easy method of purging records from the Metasys Server trend, alarm (event), and audit databases by supporting separate

screens for creating a backup prior to purging, selecting the database, and allowing for the retention of a selected number of day's data.

- ◇ Backup – Shall provide the means to create a database backup file and select a storage location.
- ◇ Restore – shall provide a restricted means of restoring a database by requiring the user to log into an Expert Mode in order to view the Restore screen.
- e. The Status Bar shall appear at the bottom of all Metasys Database Manager Tabs and shall provide information on the current database activity. The following icons shall be provided:
  - ◇ Ready
  - ◇ Purging Record from a database
  - ◇ Action Failed
  - ◇ Refreshing Statistics
  - ◇ Restoring database
  - ◇ Shrinking a database
  - ◇ Backing up a database
  - ◇ Resetting internet information Services
  - ◇ Starting the Metasys Device Manager
  - ◇ Shutting down the Metasys Device Manager
  - ◇ Action successful
- f. The Database Manager monitoring functions shall be accessed through the Monitoring Settings window and shall continuously read database information once the user has logged in.
- g. The System shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.
- h. The Monitoring Settings window shall have the following sections:
  - ◇ General – Shall allow the user to set and review scan intervals and start times.
  - ◇ Email – Shall allow the user to create and review e-mail and phone text messages to be delivered when a Warning or Alarm is generated.
  - ◇ Warning – shall allow the user to define the Warning limit parameters, set the Reminder Frequency, and link the e-mail message.
  - ◇ Alarm – shall allow the user to define the Alarm limit parameters, set the Reminder Frequency, and link the e-mail message.
  - ◇ Database login – Shall protect the system from unauthorized database manipulation by creating a Read Access and a Write Access for each of the Trend, Alarm (Event) and Audit databases as well as an Expert Mode required to restore a database.
- i. The Monitoring Settings Taskbar shall provide the following informational icons:
  - ◇ Normal – Indicates by color and size that all databases are within their limits.
  - ◇ Warning - Indicates by color and size that one or more databases have exceeded their Warning limit.
  - ◇ Alarm - Indicates by color and size that one or more databases have exceeded their Alarm limit.

- j. The System shall provide user notification via Taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.
12. Demand Limiting and Load Rolling
- a. The System shall provide a Demand Limiting and Load Rolling program for the purpose of limiting peak energy usage and reducing overall energy consumption.
  - b. The system shall be configured to support LEED Green Building certification plans.
  - c. The System shall support both Sliding Window and Fixed Window methods of predicting demand.
  - d. The System shall support three levels of sensitivity in the Sliding Window demand calculations for fine tuning the system.
    - ◇ Low Setting – Sheds loads later and over the shortest amount of time. Maximizes the time the equipment is on.
    - ◇ Medium Setting – Sheds loads earlier over a longer amount of time than the Low Setting. Increases the time the equipment is on and decreases the probability of exceeding the Tariff Target over the Low Setting.
    - ◇ High Setting – Sheds loads earlier over a longer amount of time than the Medium Setting. Minimizes the probability of exceeding the Tariff Target.
  - e. The System shall have both a Shed Mode and a Monitor Only Mode of operation.
    - ◇ When the Shed Mode is engaged, the System shall actively control the Demand.
    - ◇ When the Monitor Mode is engaged, the System will simulate the shedding action but will not take any action.
  - f. The Demand Limiting program shall monitor the energy consumption rate and compare it to a user defined Tariff Target. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined strategy.
  - g. The Demand Limiting program shall be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.
  - h. The Demand Limiting program shall be capable of supporting a minimum of 12 separate Tariff Targets defining the maximum allowed average power during the current interval.
  - i. The System shall support a Maximum Shed Time for each load as determined by the user. The system shall restore the load before the Maximum Shed time has expired.
  - j. The System shall support a Minimum Shed Time for each load as determined by the user. The system shall not restore the load sooner than the Minimum Shed Time has expired.
  - k. The System shall support a Minimum Release Time for each load as determined by the user. The System shall not shed the load until it has been off for the Minimum Release time.
  - l. The System shall support three user defined options if the meter goes unreliable.
    - ◇ Shedding – The currently shed loads will be released as their Maximum shed Times expire.
    - ◇ Maintain the Current Shed Rate – The System will use the Demand Limiting shed rate that was present when the meter went unreliable.
    - ◇ Use Unreliable Meter Shed Rate – the system will control to a user defined Unreliable Shed Rate target.

- m. The Load Rolling program shall sum the loads currently shed and compare it to a user defined Load Rolling Target. The system shall maintain consumption below the target by selectively shedding loads based upon a user defined Load Priority.
- n. The Load Rolling program shall be capable of supporting a minimum of 10 separate Load Priorities. Each load shall be user assigned to a Load Priority.
- o. The Load Rolling program shall be capable of supporting a minimum of 12 separate Tariff Targets defining the amount of power by which the demand must be reduced.
- p. The System shall provide the user with a Load Tab that displays all of the Demand Limiting and Load Rolling parameters for any selected load.
- q. The System shall provide the user with a Load Summary that displays all of the loads associated with the Demand Limiting and Load Rolling programs. Status Icons for each load shall indicate:
  - ◇ Load is Offline
  - ◇ Load is Disabled
  - ◇ Load is Shed
  - ◇ Load is Locked
  - ◇ Load is in Comfort Override
- r. The Load Summary shall include a Load Summary Runtime view listing the following load conditions:
  - ◇ Load Priority
  - ◇ Shed Strategy
  - ◇ Load Rating
  - ◇ Present Value
  - ◇ Ineligibility Status
  - ◇ Active Timer
  - ◇ Time Remaining
  - ◇ Last Shed Time

#### D. Ready Access Portal User Interface

1. BAS Contractor shall provide and install all computer hardware and software required for the purpose of configuration and consolidation of information and programs required for the delivery of a Task Focused, Web Based Portal to the BAS. This Ready Access Portal shall provide a natural, complementary extension to the site management user interface previously described.
2. Ready Access Portal Architecture – The architecture of the system shall be implemented to conform to industry standards, so that it can accommodate the required applications provided by the BAS Contractor as well as communicate information too and from the Metasys system Site Director.
3. User Interface Application Components
  - a. The ready access portal shall provide an intuitive user interface to key Metasys functions and tasks via web browser.

- b. Plug-ins or special software shall not be required for access to alarm, summary, schedule and trend data.
  - c. The information shall be accessible on both personal computer and handheld device platforms as follows:
    - ◇ Personal computers – Internet Explorer Version 7.0 recommended
    - ◇ Handheld devices – Internet Explorer for Window Mobile Version 5.0 or 6.0 recommended. UI is optimized for devices with a 240 x 320 pixel screen size (QVGA). Other devices may display the UI but full functionality is not guaranteed.
4. Operator Interface
- a. Password access shall be as described previously for management portal UI
  - b. Once logged in, the System shall display a pre-selected screen tailored to the task requirements of the individual user.
  - c. The User Interface shall utilize an intuitive navigation and display method designed for operators who access the system for casual information and control or on an infrequent basis. It shall feature three basic components.
    - ◇ Radio buttons for selection of the type of information to be displayed including Alerts, Summary, Schedules and Diagnostics
    - ◇ Navigation tree for selection of the specific data to be displayed on screen for the selected type. The navigation tree may be hidden and expanded by the operator to optimize the display of information
    - ◇ A display window that provides the selected information by type in a pre-configured tabular format
  - d. The user interface software shall provide help menus and instructions for each operation and/or application.
  - e. The system shall provide support for up to 100 concurrent users from an unlimited universe individuals with defined password access to the system
  - f. The system shall provide Secure Sockets Level (SSL) support. This allows the ready access portal to communicate across a network in a way designed to prevent eavesdropping, tampering, and message forgery. It provides endpoint authentication and communications privacy over the network using cryptography
  - g. The system shall have the capability to display multiple navigation trees that correspond to the user views configured in the management portal UI.
  - h. The alert summary of the remote access portal shall, at the minimum, provide the following information
    - ◇ Alert (Alarm) type
    - ◇ Date and time of alert occurrence
    - ◇ Priority (color coded to level)
    - ◇ Item name.
    - ◇ Item value (if applicable)
    - ◇ Message
    - ◇ Any attribute of any object in the system may be designated to report an alarm
  - i. A standard summary on the remote access portal shall, at the minimum, provide the following information
    - ◇ Point type graphic icon

- ◇ Item name
  - ◇ Item value
  - ◇ Item status
  - ◇ Access to the Change Value window (if applicable) for the purpose of setting, holding or releasing an item value
- j. The schedule detail summary of the remote access portal shall, at the minimum, provide the following information
- ◇ Scheduled occurrences including time and value
  - ◇ Scheduled overrides including start time, end time and value
  - ◇ A list of all scheduled items including name and attribute, value, status and priority
  - ◇ Access to the Add Temporary Override window for the purpose of adding a temporary override to the schedule
- k. The diagnostic (trend) summary of the remote access portal as viewed on a personal computing device shall provide the following information.
- ◇ Item name
  - ◇ Item status
  - ◇ Trend name
  - ◇ Trend status
  - ◇ Full path name
  - ◇ Access to trend detail summary including trended value, time and date arranged in a user selectable format of 1 hour, 12 hours, 24 hours, 48 hours or 72 hours

## **2.04 NETWORK AUTOMATION ENGINES (NAE)**

### **A. Network Automation Engine**

1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.
2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.
3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
  - a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
  - b. The NAE shall support up a minimum of four (4) concurrent users.
  - c. The web based user shall have the capability to access all system data through one NAE.
  - d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.
  - e. Systems that require the user to address more than one NAE to access all system information are not acceptable.

- f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.
  - g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
  - h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
    - ◇ Configuration
    - ◇ Commissioning
    - ◇ Data Archiving
    - ◇ Monitoring
    - ◇ Commanding
    - ◇ System Diagnostics
  - i. Systems that require workstation software or modified web browsers are not acceptable.
  - j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.
  5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
  6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.
  7. The NAE shall include troubleshooting LED indicators to identify the following conditions:
    - a. Power - On/Off
    - b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic
    - c. Ethernet Connection Speed – 10 Mbps/100 Mbps
    - d. FC Bus A – Normal Communications/No Field Communications
    - e. FC Bus B – Normal Communications/No Field Communications
    - f. Peer Communication – Data Traffic between NAE Devices
    - g. Run – NAE Running/NAE in Startup/NAE Shutting Down/Software Not Running
    - h. Bat Fault – Battery Defective, Data Protection Battery Not Installed
    - i. 24 VAC – 24 VAC Present/Loss Of 24VAC
    - j. Fault – General Fault
    - k. Modem RX – NAE Modem Receiving Data
    - l. Modem TX – NAE Modem Transmitting Data
  8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.
    - a. Two (2) USB port
    - b. Two (2) URS-232 serial data communication port



- c. Two (2) RS-485 port
  - d. One (1) Ethernet port
9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
  10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.
    - a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.
    - b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
  11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).
  12. Controller network – The NAE shall support the following communication protocols on the controller network:
    - a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
      - ◇ The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
      - ◇ The NAE shall be tested and certified as a BACnet Building Controller (B-BC).
      - ◇ A BACnet Protocol Implementation Conformance Statement shall be provided for the NAE.
      - ◇ The Conformance Statements shall be submitted 10 days prior to bidding.
      - ◇ The NAE shall support a minimum of 100 control devices.
    - b. The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.
      - ◇ All LonWorks controls devices shall be LonMark certified.
      - ◇ The NAE shall support a minimum of 255 LonWorks enabled control devices.

## 2.05 DDC SYSTEM CONTROLLERS

### A. Field Equipment Controller

1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.
  - a. The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
    - ◇ The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
    - ◇ The FEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
    - ◇ A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
    - ◇ The Conformance Statement shall be submitted 10 days prior to bidding.
2. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers

using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

3. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
4. The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
5. The FEC shall include a removable base to allow pre-wiring without the controller.
6. The FEC shall include troubleshooting LED indicators to identify the following conditions:
  - a. Power On
  - b. Power Off
  - c. Download or Startup in progress, not ready for normal operation
  - d. No Faults
  - e. Device Fault
  - f. Field Controller Bus - Normal Data Transmission
  - g. Field Controller Bus - No Data Transmission
  - h. Field Controller Bus - No Communication
  - i. Sensor-Actuator Bus - Normal Data Transmission
  - j. Sensor-Actuator Bus - No Data Transmission
  - k. Sensor-Actuator Bus - No Communication
7. The FEC shall accommodate the direct wiring of analog and binary I/O field points.
8. The FEC shall support the following types of inputs and outputs:
  - a. Universal Inputs - shall be configured to monitor any of the following:
    - ◇ Analog Input, Voltage Mode
    - ◇ Analog Input, Current Mode
    - ◇ Analog Input, Resistive Mode
    - ◇ Binary Input, Dry Contact Maintained Mode
    - ◇ Binary Input, Pulse Counter Mode
  - b. Binary Inputs - shall be configured to monitor either of the following:
    - ◇ Dry Contact Maintained Mode
    - ◇ Pulse Counter Mode
  - c. Analog Outputs - shall be configured to output either of the following
    - ◇ Analog Output, Voltage Mode
    - ◇ Analog Output, current Mode
  - d. Binary Outputs - shall output the following:
    - ◇ 24 VAC Triac
  - e. Configurable Outputs - shall be capable of the following:
    - ◇ Analog Output, Voltage Mode

◇ Binary Output Mode

9. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
  - a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
  - b. The FC Bus shall support communications between the FECs and the NAE.
  - c. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.
  - d. The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.
  - e. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.
  - f.
10. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
  - a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard Protocol SSPC-135, Clause 9.
  - b. The SA Bus shall support a minimum of 10 devices per trunk.
  - c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.
11. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.
12. The FEC shall support, but not be limited to, the following:
  - a. Hot water, chilled water/central plant applications
  - b. Built-up air handling units for special applications
  - c. Terminal units
  - c. Special programs as required for systems control

## 2.06 FIELD DEVICES

### A. Input/Output Module

1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.
2. The IOM shall communicate with the FEC over the FC Bus or the SA Bus.
3. The IOM shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
  - a. The IOM shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
  - b. The IOM shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
  - c. A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
  - d. The Conformance Statement shall be submitted 10 days prior to bidding.
4. The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
5. The IOM shall have a minimum of 4 points to a maximum of 17 points.

6. The IOM shall support the following types of inputs and outputs:
  - a. Universal Inputs - shall be configured to monitor any of the following:
    - ◇ Analog Input, Voltage Mode
    - ◇ Analog Input, Current Mode
    - ◇ Analog Input, Resistive Mode
    - ◇ Binary Input, Dry Contact Maintained Mode
    - ◇ Binary Input, Pulse Counter Mode
  - b. Binary Inputs - shall be configured to monitor either of the following:
    - ◇ Dry Contact Maintained Mode
    - ◇ Pulse Counter Mode
  - c. Analog Outputs - shall be configured to output either of the following
    - ◇ Analog Output, Voltage Mode
    - ◇ Analog Output, current Mode
  - d. Binary Outputs - shall output the following:
    - ◇ 24 VAC Triac
  - e. Configurable Outputs - shall be capable of the following:
    - ◇ Analog Output, Voltage Mode
    - ◇ Binary Output Mode
7. The IOM shall include troubleshooting LED indicators to identify the following conditions:
  - a. Power On
  - b. Power Off
  - c. Download or Startup in progress, not ready for normal operation
  - d. No Faults
  - e. Device Fault
  - f. Normal Data Transmission
  - g. No Data Transmission
  - h. No Communication

**B. Networked Thermostat (Fan Coils, Unit Heaters)**

1. The networked thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters or other similar equipment.
2. The TEC shall communicate over the Field Controller Bus using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
3. The TEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
  - a. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
  - b. A BACnet Protocol Implementation Conformance Statement shall be provided for the TEC.
  - c. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interface through a Network Automation Engine.
5. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
  - a. Two line, 8 character backlit display
  - b. LED indicators for Fan, Heat, and Cool status
  - c. Five (5) User Interface Keys
    - ◇ Mode
    - ◇ Fan
    - ◇ Override
    - ◇ Degrees C/F
    - ◇ Up/Down
  - d. The display shall continuously scroll through the following parameters:
    - ◇ Room Temperature
    - ◇ System Mode
    - ◇ Schedule Status – Occupied/Unoccupied/Override
    - ◇ Applicable Alarms
6. The Networked Thermostat shall provide the flexibility to support any one of the following inputs:
  - a. Integral Indoor Air Temperature Sensor
  - b. Duct Mount Air Temperature Sensor
  - c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator
  - d. Two configurable binary inputs
7. The Networked Thermostat shall provide the flexibility to support any one of the following outputs:
  - a. Three Speed Fan Control
  - b. Two On/Off
  - c. Two Floating
  - d. Two Proportional (0 to 10V)
8. The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.
9. The Networked Thermostat shall provide the flexibility to adjust the following parameters:
  - a. Adjustable Temporary Occupancy from 0 to 24 hours
  - b. Adjustable heating/cooling deadband from 2° F to 5° F
  - c. Adjustable heating/cooling cycles per hour from 4 to 8
10. The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

**C. VAV Modular Assembly**

1. The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.

2. The VMA shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
  - a. The VMA shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
  - b. A BACnet Protocol Implementation Conformance Statement shall be provided for the VMA.
  - c. The Conformance Statement shall be submitted 10 days prior to bidding.
3. The VAV Modular Assembly shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.
4. The VAV Modular Assembly shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
5. The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.
6. The VAV Modular Assembly shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
7. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
8. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
9. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
10. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
11. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
12. The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.
13. Control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
14. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
15. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.
16. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
17. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages

(EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

- ◇ Absolute temperature loop error
- ◇ Signed temperature loop error
- ◇ Absolute airflow loop error
- ◇ Signed airflow loop error
- ◇ Average damper actuator duty cycle

18. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

- ◇ Unreliable space temperature sensor
- ◇ Unreliable differential pressure sensor
- ◇ Starved box
- ◇ Actuator stall
- ◇ Insufficient cooling
- ◇ Insufficient heating

The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

19. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.

20. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

21. Inputs:

a. Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

- ◇ 0-10 VDC Sensors
- ◇ 1000ohm RTDs
- ◇ NTC Thermistors

b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."

c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

d. Provide side loop application for humidity control.

22. Outputs

a. Analog outputs shall provide the following control outputs:

- ◇ 0-10 VDC

b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

- c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.
- 23. Application Configuration
  - a. The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.
- 24. Sensor Support
  - a. The VAV Modular Assembly shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.
  - b. The VMA shall support an LCD display room sensor.
  - c. The VMA shall also support standard room sensors as defined by analog input requirements.
  - d. The VMA shall support humidity sensors defined by the AI side loop.

**D. Network Sensors (Temp, Humidity, Zone, DAT)**

- 1. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:
  - a. Zone Temperature
  - b. Zone Humidity
  - c. Zone Setpoint
  - d. Discharge Air Temperature
- 2. The NS shall transmit the information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.
- 3. The NS shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
  - a. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).
  - b. A BACnet Protocol Implementation Conformance Statement shall be provided for the NS.
  - c. The Conformance Statement shall be submitted 10 days prior to bidding.
- 4. The Network Zone Sensors shall include the following items:
  - a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint
  - b. An LED to indicate the status of the Override feature
  - c. A button to toggle the temperature display between Fahrenheit and Celsius
  - d. A button to initiate a timed override command
  - e. Available in either surface mount or wall mount
  - f. Available with either screw terminals or phone jack
- 5. The Network Discharge Air Sensors shall include the following:
  - a. 4 inch or 8 inch duct insertion probe
  - b. 10 foot pigtail lead
  - c. Dip Switches for programmable address selection
  - d. Ability to provide an averaging temperature from multiple locations
  - e. Ability to provide a selectable temperature from multiple locations

**2.07 SYSTEM TOOLS**



**A. System Configuration Tool (SCT)**

1. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Automation Engine (NAE) or a Network Integration Engine (NIE).
2. The configuration tool shall provide an archive database for the configuration and application data.
3. The configuration tool shall have the same look-and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.
4. The configuration tool shall include the following features:
  - a. Basic system navigation tree for connected networks
  - b. Integration of Metasys N1, LonWorks, and BACnet enabled devices
  - c. Customized user navigation trees
  - d. Point naming operating parameter setting
  - e. Graphic diagram configuration
  - f. Alarm and event message routing
  - g. Graphical logic connector tool for custom programming
  - h. Downloading, uploading, and archiving databases
5. The configuration tool shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:
  - a. BACnet Devices
  - b. LonWorks devices
6. The configuration tool shall be capable of programming the Field Equipment Controllers.
  - a. The configuration tool shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.
  - b. The configuration tool shall allow the FECs to be run in Simulation Mode to verify the applications.
  - c. The configuration tool shall contain a library of standard applications to be used for configuration.
7. The configuration tool shall be capable of programming the field devices.
  - a. The configuration tool shall provide the capability to configure, simulate, and commission the field devices.
  - b. The configuration tool shall allow the field devices to be run in Simulation Mode to verify the applications.
  - c. The configuration tool shall contain a library of standard applications to be used for configuration
8. A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.
  - a. The wireless connection shall allow the PC to access configuration tool through the web browser using the User Interface (UI).
  - b. The wireless use of configuration tool shall be the same as a wired connection in every respect.
  - c. The wireless connection shall use the Bluetooth Wireless Technology.

## **PART 3 –EXECUTION**

### **3.01 INSTALLATION PRACTICES**

#### **A. BAS Wiring**

1. All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BAS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.
3. The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
4. Class 2 Wiring
  - a. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.
  - b. Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
5. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
6. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

#### **B. BAS Line Voltage Power Source**

1. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.
2. Circuits used for the BAS shall be dedicated to the BAS and shall not be used for any other purposes.
3. DDC terminal unit controllers may use AC power from motor power circuits.

#### **C. BAS Raceway**

1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".
2. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
3. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

#### **D. Penetrations**

1. Provide fire stopping for all penetrations used by dedicated BAS conduits and raceways.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

E. BAS Identification Standards

1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

F. BAS Panel Installation

1. The BAS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. The BAS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

G. Input Devices

1. All Input devices shall be installed per the manufacturer recommendation
2. Locate components of the BAS in accessible local control panels wherever possible.

H. HVAC Input Devices – Genera1

1. All Input devices shall be installed per the manufacturer recommendation
2. Locate components of the BAS in accessible local control panels wherever possible.
3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.
4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.
5. Outside Air Sensors
  - a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.
  - b. Sensors shall be installed with a rain proof, perforated cover.
6. Water Differential Pressure Sensors
  - a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
  - b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
  - c. The transmitters shall be installed in an accessible location wherever possible.
7. Medium to High Differential Water Pressure Applications (Over 21" w.c.):
  - a. Air bleed units, bypass valves and compression fittings shall be provided.
8. Building Differential Air Pressure Applications (-1" to +1" w.c.):
  - a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.
  - b. The interior tip shall be inconspicuous and located as shown on the drawings.
9. Duct Temperature Sensors:

- a. Duct mount 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.
  - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
  - c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.
  - d. The sensor shall be mounted to suitable supports using factory approved element holders.
10. Space Sensors:
    - a. Shall be mounted per ADA requirements.
    - b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.
  11. Low Temperature Limit Switches:
    - a. Install on the discharge side of the first water or steam coil in the air stream.
    - b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.
    - c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.
  12. Air Differential Pressure Status Switches:
    - a. Install with static pressure tips, tubing, fittings, and air filter.
  13. Water Differential Pressure Status Switches:
    - a. Install with shut off valves for isolation.
  14. Air Flow Monitoring Devices
    - a. Provide Ebtron Gold Meters per manufacturer's recommendation
- I. HVAC Output Devices
1. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.
  2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. .
  3. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.
  4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.
  5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

### **3.02 TRAINING**

- A. The BAS contractor shall provide the following training services:

1. Two days of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BAS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

### **3.03 COMMISSIONING REQUIREMENTS**

- A. Fully commission all aspects of the Building Management System work.
- B. Acceptance Check Sheet
  1. Prepare a check sheet that includes all points for all functions of the BAS as indicated on the point list included in this specification.
  2. Submit the check sheet to the Engineer for approval
  3. The Engineer will use the check sheet as the basis for acceptance with the BAS Contractor.
- C. VAV box performance verification and documentation:
  1. The BAS Contractor shall test each VAV box for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.
  2. The BAS Contractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.
- D. Promptly rectify all listed deficiencies and submit to the Engineer that this has been done.

### **3.04 END OF SECTION**

# HAYWOOD SOLAR DEVELOPMENT PROJECT

## PUMP SCHEDULE - ELECTRICAL

PUMP SCHEDULE															
MARK	BASIS OF DESIGN			LOCATION	TYPE	SERVICE	CAPACITY (GPM)	TOTAL HEAD (FT H2O)	SPEED (RPM)	CONNECTION SIZE (IN.)		MOTOR HP	IMPELLER	ELECTRICAL VOLTS/ & /HZ	NOTES
	MANUFACTURER	SERIES	MODEL							SUCTION	DISCHARGE				
SFP-1A	BELL & GOSSETT	1510	2-1/2BB	MECH ROOM 7009	BASE MOUNT	SOLAR WATER FIELD	250	60	1750	3.0	2.5	7.5	8.375"	460/3/60	1, 2
SFP-1B	BELL & GOSSETT	1510	2-1/2BB	MECH ROOM 7009	BASE MOUNT	SOLAR WATER FIELD	250	60	1750	3.0	2.5	7.5	8.375"	460/3/60	1, 2
SP-1A	BELL & GOSSETT	1510	1-1/2AB	MECH ROOM 7009	BASE MOUNT	SOLAR TANK SUPPLY	150	20	1750	3.0	2.5	1.5	5.25"	460/3/60	
SP-1B	BELL & GOSSETT	1510	1-1/2AB	MECH ROOM 7009	BASE MOUNT	SOLAR TANK SUPPLY	150	20	1750	3.0	2.5	1.5	5.25"	460/3/60	
P-1A	BELL & GOSSETT	1510	1-1/2AC	MECH ROOM 7009	BASE MOUNT	HOT WATER SECONDARY	100	45	1750	2.0	1.5	3.0	6.875"	460/3/60	1, 4
P-1B	BELL & GOSSETT	1510	1-1/2AC	MECH ROOM 7009	BASE MOUNT	HOT WATER SECONDARY	100	45	1750	2.0	1.5	3.0	6.875"	460/3/60	1, 4
P-2B	BELL & GOSSETT	PL-36	-	MECH ROOM 7009	IN LINE	HOT WATER PRIMARY	25	20	3300	1.5	1.5	0.17	-	120/1/60	3
P-2B	BELL & GOSSETT	PL-36	-	MECH ROOM 7009	IN LINE	HOT WATER PRIMARY	25	20	3300	1.5	1.5	0.17	-	120/1/60	3
RP-1	GRUNDFOS	15/42		MANIFOLD CABINETS	IN LINE	UNDER FLOOR RADIANT HEAT	0-25	15	-	3/4	3/4	1/12	1/12	115/1/60	

NOTES:  
 1. PROVIDE WITH VFD.  
 2. PUMP HEAD BASED ON SOLAR PANEL PRESSURE DROP.  
 3. POWER PROVIDED BY BOILER PACKAGE SINGLE POINT CONNECTION.  
 4. TO BE OPERATED IN PARALLEL.

## PUMP SCHEDULE - MECHANICAL

PUMP SCHEDULE									
MARK	BASIS OF DESIGN	GPM	FT. OF HEAD	BASIN DESIGN		RPM	HP	ELECTRICAL	REMARKS
				DEPTH	DIMENSIONS				
SP-1	WEIL 1622 TWO PUMPS IN CISTERN	40	40	--	--		2.0	460/3/60	RAINWATER SUPPLY SUMP
SP-2	BELL AND GOSSETT 2WF1012H	50	25	24"	18"x18"	3500	1	230/1/60	ELEVATOR SUMP
BP-1	BELL AND GOSSETT HYFAB MVP-630-460	50	45 PSI	--	--		3.0	460/3/60	DOMESTIC BOOSTER
SWP-1	BELL AND GOSSETT PD-40	50	30	--	--	1750	1.0	208/3/60	SOLAR PANEL PUMP
DRP-2	BELL AND GOSSETT LR-15B	10	15	--	--	3300	0.17	115/1/60	DOMESTIC STORAGE RECIRCULATOR
HWRP-1	BELL & GOSSETT MODEL PL-36	5	25	--	--	3300	0.17	115/1/60	HOT WATER RECIRCULATOR

1. PC TO PROVIDE STARTERS FOR BP-1 AND SWP-1.  
 2. PC TO PROVIDE DISCONNECT FOR DRP-2 AND HWRP-1  
 3. PROVIDE PUMP MOTOR MOISTURE ALARM.  
 4. SUMP PUMP ALARMS SHALL BE TIED INTO BAS.  
 5. PROVIDE RAIL REMOVAL SYSTEM FOR PUMPS IN SP-1. WEIL ITEM NUMBER 2163-2  
 6. BP-1 TO BE FACTORY BUILD SKID MOUNTED WITH VFD'S

INNOVATIVE DESIGN  
 850 W. MOARGAN ST.  
 RALEIGH, NC 27603  
 919-832-6303