NC State University Design and Construction Guidelines
Division 23 Campus Automation

1.0 Purpose

A. The following guideline outlines standards for campus automation.

2.0 General Requirements

A. System Features and Architecture

1. The controls system shall be web based, capable of integrating multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.
2. HVAC controls system contractor shall provide a fully integrated system, UL listed, incorporating direct digital control for energy management, equipment monitoring and control.
3. Building systems which require an emergency generator shall have a control system with UPS for all affected control panels.
4. The installer shall have at least 10 years of experience and be approved by the manufacturer for both installation and maintenance of building systems and equipment.
5. There shall be only one Ethernet connection per building to the university wide area network. The Ethernet connection shall not be located in NC State telecommunication rooms.
6. The sequence of operations for the building shall be available on the graphical webpage for the building systems, either through a link to a HTML page or a PDF.
7. In buildings and spaces requiring strict individual room humidity and/or air quality control, a multiple point air quality monitoring system shall be provides.

B. Submittals

1. Product Data shall include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Each control device shall be labeled with setting or adjustable range of control.
2. Shop Drawings shall detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Include:
    a) Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
    b) Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.

c) Details of control panel faces, including controls, instruments, and labeling.

d) Written description of sequence of operation.

e) Schedule of dampers including size, leakage, and flow characteristics.

f) Schedule of valves including size, leakage, and flow characteristics.

g) Trunk cable schematic showing programmable control unit locations and trunk data conductors.

h) Listing of connected data points, including connected control unit and input device.

i) System graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations.

j) System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

3. Software and Firmware Operational Documentation shall include:

a) Software operating and upgrade manuals.

b) Program Software Backup on a jump drive or compact disc, complete with data files.

c) Device address list.

d) Printout of software application and graphic screens.

e) Software licenses required by and installed for Direct Digital Controller (DDC) workstations, laptops, engineering tools and control systems.

f) Software upgrade kit for use in modifying control software or web pages to suit future power system revisions or monitoring and control revisions.

C. Maintenance Data shall include:

1. Instructions and lists of spare parts for each type of control device and compressed air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.
5. Control drawings recording actual locations of control components, including control units, thermostats, and sensors.
6. Systems Architecture - refer to Addendum C.

D. Warranty and Service

1. The Contractor shall warrant the system to be free from defects in material and workmanship for a period of two (2) years from the date of completion and acceptance of the work by the owner.
2. The Contractor shall provide one (1) year of maintenance service for the Heating Ventilating and Air Conditioning (HVAC) controls system to begin concurrently with the first year of warranty. Service shall include inspection and adjustment of all operating controls and components during the alternate season commissioning effort. A service report shall be provided to NC State.

E. Furnish the following extra materials to NC State at completion:

1. One (1) sensor of each type (Hydronic, air supply, humidity)
2. Two (2) zone thermostats
3. Two (2) sets of filters for the compressed air system

3.0 Materials & Standards

A. Direct Digital Controller (DDC) Equipment (workstations, laptops, printers, software, DDC control units)

1. Building Control Unit (BCU)
   a) Provide a minimum of one (1) BCU per building.
   b) The BCU shall be a networking stand alone energy management panel enclosed in a minimum of 18 ga. metal enclosure. The microcomputer shall be 16 bits minimum. The microcomputer shall utilize a multi-tasking, multi - user operating system. The BCU shall have peripheral ports for a monitor, a printer, network communications, and have storage capacity for the entire database, including set points. The BCU shall have a battery back -up for the clock.
   c) The BCU shall be placed on the control vendor's Local Area Network (LAN) configuration within the building via its BUS ports. The LAN's fault tolerant operation shall guarantee that despite failure of individual DDC controllers, remaining units will continue communication uninterrupted. The BCU shall also be connected to the Campus Wide Area Network via Ethernet connection with communications based on TCP/IP protocol. This connection is via one of the Ethernet ports. The BCU shall be furnished with a built in software library.
   d) The Ethernet card shall reside in the BCU. It shall communicate with the network via a 100 Mbps network adapter.
   e) The BCU shall have an operator interface port that allows a laptop to direct connect to the BCU and the individual local controllers. The

interface connection shall provide all necessary communication to allow the laptop to display analog variables, binary (status) condition, adjustment values, automatic operation, trouble, alarm condition and value, and manual or override condition.

f) A standard NC State voice/data outlet shall be installed adjacent to the BCU. The building control contractor shall be responsible for all Ethernet wiring, routers, or other hardware associated with Ethernet communication within the control system LAN. Control system Ethernet wiring shall not reside in the NC State telecom raceways.

g) A laptop computer shall be provided, including software that is capable of communication with the controls network through the BCU connection.

(1) The laptop shall have all engineering software loaded and operational so that local control sequences can be modified as well as global control and point mapping in the BCU.

(2) The laptop shall be provided with all necessary communication cables and communication adapters to direct connect to local controllers as well as the BCU.

2. DDC Controllers

a) DDC Controllers (stand-alone) shall be microprocessor-based with a minimum word size of 16 bits. They shall be multi-tasking, multi-user, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules.

b) Control of the mechanical systems shall be performed by a field programmable microprocessor-based DDC, which incorporates closed loop control algorithms, all necessary energy management functions.

c) Each unit shall, at a minimum, be capable of performing the following energy management functions:

(1) Start/stop optimization

(2) Time of day scheduling

(3) Enthalpy economizer control

(4) Supply air reset

(5) Chilled water reset

(6) Hot water reset

(7) Event initiated programs

(8) Night setback

(9) Chiller sequencing

(10) Chiller load monitoring

d) Each DDC shall be capable of performing all specified control functions in a completely independent manner. Additionally, DDCs shall be capable of being networked for single point programming and for the sharing of information between panels, including, but not limited to, sensor values, calculated point values, control set-points, tuning parameters, and control instructions.

e) Each DDC microprocessor shall include its own microcomputer controller, power supply, input/output modules, termination modules, battery, and spare AC outlet. The battery shall be continuously charged and be capable of supporting all memory for a minimum of 72 hours. Upon restoration of system power, the control unit shall resume full operation without operator intervention.

3. Building Operator Workstation: Provide as a minimum Windows compatible microcomputer with minimum configuration as follows:

a) Intel .2.5 GHz or better core two duo processor, 8 GB RAM, 1 MB Cache.

b) SVGA graphics, minimum 1280 x 1024 pixels, 1 MB video memory.

c) Minimum 22" inches, noninterlaced, color, LCD monitor.

d) Standard keyboard, mouse and 1 GB flash drive.

e) 80 GB or larger hard-disk drive.

f) 48x CD/DVDR-RW Drive.

g) Easily accessible USB ports on the front of the CPU, Keyboard or Monitor.

h) Gigabit Ethernet card

i) Microsoft Windows 7 Professional operating system, 32 bit.

4. Graphic Display Requirements

a) A Windows-based software package for the preparation of system graphics shall be provided. It shall include a library of HVAC symbols such as fans, pumps, chillers, etc.

b) All operator workstations including the laptop shall be capable of displaying the graphical representations of the mechanical systems, etc. as provided by the campus web servers.

c) All displays shall show real time data to include temperatures and run status.

d) NC State shall approve all graphic pages prior to installation on the web servers.

5. Application Software shall include:
   a) Input/output capability from operator station.
   b) Operator system access levels via software password.
   c) Database creation and support.
   d) Dynamic color graphic displays.
   e) Alarm and event processing
   f) Data collection.
   g) Graphic development on workstation.
   h) Maintenance management.

6. Laptops at a minimum shall be a Windows-compatible laptop with configuration as follows:
   a) Windows type I7 processor 8 GB RAM 1 MB Cache.
   b) 1 MB of dedicated video memory graphics.
   c) 17" Active matrix, color screen.
   d) 8 GB flash drive.
   e) 40.0 GB hard-disk drive.
   f) 48x CD/DVDR-RW drive.
   g) Microsoft Windows 7 Professional Operating System, 32 bit

B. Control Panel

1. Panels shall have hinged doors with engraved labels. Panels used as a location for mounting control devices shall have a document holder located on the inside of the door.
2. Provide common keying for all panels
3. Entrance and exit wiring shall be on the panel sides.
4. All heat generating devices shall be located at the top of the panel.

C. Sensors and Transmitters

1. Humidity sensor parameters shall be:
   a) Accurate to +/- 3%
   b) Accurate to 20 – 90 % RH for room sensors. Cover to match room thermostat.
   c) Accurate to 0 – 100% RH for duct and outside air sensors
   d) Accurate to +/- 2% for outside air humidity sensors
2. Duct static pressure sensors shall have an accuracy of +/-1% of range.

3. Temperature Sensors
   a) Temperature sensors shall be platinum or nickel RTD, 100 or 1000 ohm, accurate to +/-0.5% or 10,000 ohm thermistors accurate to +/-0.5%
   b) Outside air sensors shall be shielded from solar radiation by both installation location and finned radiant energy rejection container.
4. Pneumatic transducers shall be a minimum 1¼" pressure gauge or LCD pressure display at the output of each I/P and E/P transducer.
5. Device load monitoring having current sensors shall have a proof of run for pumps and fans by current sensed devices. If the proof of run cannot be adjusted to take into account variable speed operation and loss of load, then an alternative device must be provided to confirm loss of load. Proof of motor operation shall also be provided.

D. Thermal Airflow Station

1. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
2. Description: Airflow station shall consist of one or more sensor probes and a remotely mounted microprocessor-based transmitter.
3. Performance:
   a) Capable of independently processing up to 16 independently wired sensor assemblies.
   b) Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   c) Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   d) Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
   e) Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
   f) Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
   g) Airflow Accuracy: Within 3 percent of reading over the entire operating airflow range.
      (1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
      (2) Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.

(3) Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.

(4) Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.

(5) Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.

(6) Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.

(7) Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.

(8) Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 2 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

4. Sensor Assemblies:

a) Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

b) Mount thermistors in sensor using a marine-grade, waterproof epoxy.

c) Thermistor leads shall be protected and not exposed to the environment.

d) Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.

e) Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.

f) Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.

g) Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

5. Casing:

a) Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.

b) Material: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.

c) Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.

d) Casing Depth: At least 8 inches.

e) Include casing inlet and discharge connections with a minimum1.5-inch face flange.

6. Transmitter:

a) Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.

b) Capable of field configuration and diagnostics using an onboard push-button interface and digital display.

c) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:

d) Integral protection from transients and power surges.

e) Circuitry to ensure reset after power disruption, transients, and brownouts.

E. Space Thermostats

1. All room thermostats in labs, classrooms and offices shall have exposed setpoint adjustment with internal stops or software stops for minimum and maximum setting initially set between 68°F and 76°F. All room thermostats in public areas shall have concealed setpoint adjustments with blank cover.

2. Thermostats shall not be mounted on exterior walls.

3. Thermostat accuracy shall be +/-0.5%.

F. Control Valves and Actuators

1. All butterfly valves and globe valves over three (3) inches, actuators, and dampers greater than 36 SF shall utilize pneumatic actuation. Butterfly valves for air handling unit coil control are unacceptable.

2. An alarm shall be sent to the BAS if preheating and cooling valves are simultaneously open.

3. Operator bodies shall be metal.

4. Steam valves shall have a 1/3, 2/3 valve configuration on all hot water converter applications. The 1/3 valve shall be normally open and the 2/3 valve shall be normally closed. A separate Analog Output (AO) pneumatic output shall be used for each valve.

5. Hydronic Valves

a) Non pressure independent control valves shall be sized so that pressure drop across valve is at least 25% of the coil pressure drop at full design flow.

b) For systems attached to the campus chilled water loops, programmable pressure independent control valves shall be used at all cooling coils including small fan-coil units. Globe, butterfly or ball valves with automatic flow limiting devices attached are not acceptable.

c) Valves shall remain closed (zero leakage) against 100% of the full shutoff head of the pump.

d) High performance butterfly valves shall have adjustable packing, EPDM seat with metal back-up ring, upper and lower shaft thrust bearings, 316 SS one piece shaft and 316 SS disc with offset shaft/disc design. Valves shall be provided with pneumatic actuator and positioner.

e) Two-position valves shall be line size.

f) Valve service rating shall be a minimum of 125 psig except that valves in the campus chilled water piping prior to chilled water pump shall be rated to a minimum of 250 psig. The shaft to which the actuator(s) is coupled shall have at least one flat side.

g) Terminal reheat valves and actuators shall be electric proportional, 4-20 ma or 0–10 VDC control signal. Floating point or step control is unacceptable. Characterized flow ball valves are required.

h) Valves shall have stainless steel trim and seat.

G. Dampers and Actuators

1. Dampers shall have:

a) Maximum blade width of eight (8) inches with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.

b) Low leakage control dampers if not included with packaged units. Damper leakage rate shall not exceed 10 CFM/sq. ft. at four (4) inch wg. Dampers shall have blade seals and stops. The shaft to which the actuator(s) is coupled shall be square or hexagonal or round with one side flattened.

c) Electric damper actuators for dampers in VAV terminal units. Damper actuators shall be located outside of the air stream.

d) Control dampers for outside air or exhaust installed a minimum of 12 inches away from wall penetrations to allow for external mounting of actuators.

e) Throttling operation shall be opposed blade type.

2. Actuator operator bodies shall be metal except for VAV box actuators. Damper and VAV box actuators shall couple directly.

H. Pneumatic Air Supply

1. Compressor and Accessories

a) Duplex air compressor system with a maximum duty cycle of 40 percent shall be provided. Compressor shall be selected to match ambient room conditions to allow for proper operation.

b) An electrical alternation set with motor starters and disconnect shall be provided in order to operate compressors alternately. If single unit is unable to maintain pressure, the second unit shall start automatically.

c) A refrigerant or desiccant type dryer capable of dew point reduction to less than 10°F at 5 psig shall be provided. A desiccant dryer shall be the automatic heatless regenerative type with compressor sized for blow down load.

d) Exterior air actuated devices shall include a desiccant dryer capable of lowering the dew point to -10°F.

e) All dryers shall be sized for 100 percent runtime of compressors.

f) A zero loss automatic moisture trap on the receiver drain shall be provided with the trap discharging to the mechanical room floor drain.

g) All blow downs shall be muffled.

2. Control and Instrumentation Tubing

a) Copper

(1) Seamless copper tubing shall be hard drawn Type M

(2) Soft copper tubing may be used in maximum two (2) foot lengths for connection to control devices only.

(3) Fittings shall be cast-bronze solder fittings or wrought-copper solder fittings. Use compression type fittings only for connections to control devices

b) Plastic

(1) Tubing shall be black virgin polyethylene

(2) Fittings shall be Compression or push-on polyethylene

(3) Plastic tubing should be installed only in panels or at final connection point to device (i.e. connection to valve actuator can be plastic tubing 2' for less, but run to device must be copper).

I. Labels and Tags

1. Provide labels for all field devices including sensors, meters, transmitters and relays. Labels shall be plastic laminate and located adjacent to the device.

2. Labels of field devices (both locally and software ID's) shall be associated with their respective air handler, boiler, chiller, etc.
3. Junction box covers shall be painted yellow and labeled "DDC"
4. VAV box label locations indicated on ceilings shall be printed on plastic acetate with adhesive backing.

J. Control wiring shall be a minimum of 18 gauge.

4.0 Installation

A. Control Logic

1. Secondary chilled water pump logic shall include:
   a) Variable pump speed to maintain differential pressure
   b) Utilization of VSD status for pump status and pump differential pressure switches for flow status.
   c) Backup pumps shall start based on low differential pressure or VSD faults.
   d) A by-pass pump for operation when campus system pressure is adequate. When campus system pressure is low, by-pass pump is de-energized and building pump shall run.

B. Control and Instrumentation Tubing

1. Purge tubing with dry, oil-free compressed air before connecting control instruments.
2. Number-code or color-code control air piping for future identification and service of control system.
3. Install pressure gauges on branch lines at each controller panel and on signal lines at each transmitter.
4. All tubing in mechanical rooms shall be either hard drawn copper or poly tubing in conduit.
5. All tubing in concealed and inaccessible locations such as concrete slabs, furred walls or ceiling with no access shall be copper. Copper tubing in concrete shall be in PVC conduit.

C. Control Wiring

1. All wiring shall be in conduit. Conduit shall be run parallel or perpendicular to walls and building lines. Junction box covers shall be painted yellow and labeled "DDC".

2. Wires shall be labeled with mechanically prepared labels at their connection point to each apparatus point of connection.
3. Wiring shall not use the voice/data wire way/conduit systems as pathways.
4. Plenum cable shall not be used.

D. The controls contractor shall perform the following on-site testing once installation is complete:

a) A 100% field calibration of all sensors and equipment.
b) Verification of each control point by comparing the control command and the field device.
c) Documentation of results provided to NC State prior to final acceptance.

E. Demonstration shall occur if project not formally commissioned

1. The controls contractor shall demonstrate that controls are installed, adjusted and operate as required by the drawings and specifications. This demonstration shall be documented and shall be conducted in conjunction with NC State personnel training. The documentation shall identify the item, the person performing the demonstration, the date, and the signature of the NC State representative. The Representative will select the items to be demonstrated. Items shall be demonstrated as follows:

a) Disconnect one DDC from the building network to demonstrate that a single device failure will not disrupt peer-to-peer communication
b) Manually generate alarms at 10% of the installed alarmed points and demonstrate that the workstation receives the alarms.
c) Provide documentation that calibration has been performed on 100% of the sensors.
d) Provide point-to-point verification of 25 % of all points. Include labeling of all points.
e) Demonstrate the complete sequence of operation for the air handling.
f) Demonstrate the complete sequence of operation for the chilled water system including chiller(s).
g) Demonstrate the complete sequence of operation for the hot water system.
h) Demonstrate the complete sequence of operation for the boiler and steam system.
i) Demonstrate the complete sequence of operation of the HVAC controls system during a fire alarm.
j) Demonstrate the complete sequence of operation for 25% of VAV terminal units.

k) Demonstrate graphics system is functional and the layout is consistent with field conditions.

l) Demonstrate response to upset conditions and change of setpoint for all major systems for items listed in e-i above.

F. Training

1. The manufacturer and the controls contractor shall provide on-site training in the maintenance and operation of the installed system for up to six (6) personnel. The training shall be documented and a syllabus and O&M manuals shall be submitted and approved by NC State two (2) weeks prior to the training. The training shall include the following:

a) HVAC systems layout including the locations of air handlers, DDC controllers, VAV boxes, pumps, and chillers. This will include a walk-thru of the building.

b) Sequence of operations for each control loop.

c) Accessing the control system including:

(1) Logon procedure

(2) Use of graphic and DDC pages

(3) Password requirements

d) Operation and troubleshooting including:

(1) Modification of setpoints, and schedules

(2) Overview of graphics and text pages

(3) Trending of points

(4) Calibration and adjustment

(5) Hands-on training in the troubleshooting and replacement of components including sensors, transmitters, control valves and actuators. Contractor shall have examples of each component and demonstrate measurement of input and output signals, and any operator adjustments available.

(6) DDC controller functions and operation

e) Review of O&M manual and control system as-builts

2. The controls contractor shall provide an additional on-site training session nine (9) months after project completion. The purpose of the session will be to review any operational problems that have developed. In addition, the contractor will lead NC State personnel through a comprehensive annual preventative maintenance of the controls system. This shall be scheduled at least one (1) month in advance.

3. The manufacturer and the controls contractor shall provide training for two (2) NC State employees at the manufacturer's training facility. Include all travel,

lodging and expenses for the trainer or NC State personnel. The training shall be documented and a syllabus must be submitted and approved by NC State prior to the training. The training should include the following:

a) Programming logic changes both local control and system (BCU)

b) Expansion of the control system including hardware and software additions

c) Graphics generation

d) HVAC control systems

APPENDIXES

A. Sample I/O Summary (to be included on the contract drawings)
B. Minimum Points – Display and programming requirements
C. Campus and building control schematic

Appendix A SAMPLE INPUT/OUTPUT SUMMARY

	ANALOG														BINARY										COMMANDABLE			SYSTEM FEATURES																		GEN.			
	MEASURED								CALCULATED																POS.			GRAD.			ALARMS						PROGRAMS													
POINT DESCRIPTION	Temperature	Pressure	RH	KW	Flow Rate	Total Pressure	Static Pressure	Diff. Pressure	KWH	Enthalpy	Run time	BTU	GPM	Status	Filter	Smoke	Freeze	Off-Slow-fast	Hi-Lo (Pressure, ect	Off/On	Off-Auto-On	Cntrl. Pt. Adj.	Dmpr. Pos.	Hi Analog	Low Analog	Hi Binary	Low Binary	Proof	Time Scheduling	Demand Limiting	Duty Cycle	Start/Stop Op.	Enthalpy Op	Reset	Event Program	DDC	Color Graphic	NOTES
NOTES																																															

APPENDIX B – Minimum Points - Display and programming requirements

The following commands, displays and data shall be available at the operator's terminal:

A. Air Handling Unit:
   1. Outside air temperature
   2. Mixed air temperature
   3. Supply air temperature
   4. Supply air temperature reset
   5. Return air temperature
   6. Fan status
   7. Cooling/heating valve position (% of full open)
   8. Static pressure test
   9. Real time display from air flow station
   10. The following points are only required if required by control strategy.

      a. Calculated total outside air flow (cfm)
      b. Damper positions (% of full open)
      c. Duct static pressure
      d. Fan speed (% of full speed)
      e. Freeze protection status
      f. Alarms (temperature, flow)
      g. Outside air humidity
      h. Humidity valve position (% of full open)

B. Hot Water Steam Converters and Pumps:
   1. Pump status
   2. Flow status
   3. Supply and return temperature
   4. Valve positions (% of full open)
   5. Pump speed if variable speed drive (% of full speed)

C. Chilled Water System:
   1. Supply and return temperature
   2. Condenser water supply and return temperature
   3. Supply temperature reset
   4. Chilled water pump status (current sensor)
   5. Condenser water pump status (current sensor)
   6. Cooling tower fan status
   7. Chiller status

8. High/low temperature alarms
9. Complete integration by protocol of all internal points
10. Building connects for campus loop systems
11. Building entry supply and return and pressure differential
12. The following points are only required if required by control strategy

    a. Secondary/tertiary supply and return temperature
    b. Secondary/tertiary flow (GPM)
    c. Bridge flow (GPM)
    d. Secondary/tertiary pump speed (% of full speed)
    e. Return water temperature control valve (% of full open)
    f. Secondary/tertiary loop differential pressure

D. Boiler and Steam System
1. Boiler status
2. Common header pressure
3. Integration to internal boiler points and open protocol

E. Air Terminals:
1. Current space temperature
2. Occupied setpoint
3. Unoccupied setpoint
4. Current status
5. Minimum and Maximum air flow setting (CFM)
6. Current air flow reading (CFM)
7. Reheat valve position (% of full open)
8. High/low temperature alarm

APPENDIX C – Campus and building control schematic