Design Guidelines for Facilities Construction:

DESIGN GUIDELINE DG25-9 Building Automation System & Controls

Western Michigan University Building Automation System & Controls Policy

Western Michigan University in its endeavor to meet quality building automation system and controls standards has developed this Building Automation System & Controls Design Guideline for new and redevelopment projects on University property.

The Design Guideline will be utilized on all new projects from this date forward by the University and its contracted Professionals.

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Part 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS), utilizing Direct Digital Controls (DDC) as shown on the drawings and as described herein. Drawings are diagrammatic only.

B. All labor, material, equipment and software not specifically referred to herein or on the plans that are required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

C. WMU’s Energy Systems Specialist shall be given administrator level software access to all building automation system controllers installed on campus, including third party controllers supplied as packaged equipment controllers and purchased separately from the control system.
1.2 SYSTEM DESCRIPTION

A. The entire Temperature Control System (TCS) shall be comprised of a Niagara\textsuperscript{AX} Server, Niagara\textsuperscript{AX} Network Area Controller or Controllers (NAC), and a network of interoperable, stand-alone digital controllers communicating via the LonTalk and/or BACnet and/or Modbus communication protocols to the Niagara\textsuperscript{AX} Network Area Controllers (NAC).

B. The Niagara\textsuperscript{AX} NAC and Supervisor shall connect to the WMU wide area network (all NACs shall be connected to VLAN 260) and communicate to all WMU systems. This means that all monitoring and control points can be accessed from, and/or transferred to or from the existing Building Automation System (BAS). Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network.

C. LonWorks is the preferred communication protocol for stand-alone digital controllers, VFDs, and other unitary controllers. It should always be considered first and not used only if it is not an option, or if a gateway is required for its use, or if there is significant additional cost associated with its use.

D. Electronic steam control valve actuators must have a labeled ("Test Trap ") pushbutton switch located within 10 feet of the actuator that will fully open the valve for a period of 5 minutes (adjustable). If there is a 1/3 - 2/3 valve arrangement it shall open only the 1/3 valve. This provision is to allow pipe fitters to test the associated steam traps without the assistance of others. The pushbutton switch shall be connected to the BAS and shall generate a BAS override alarm when pushed. The test mode shall also be displayed on the appropriate BAS graphics.

E. Cooling tower condenser supply 3-way valves shall have a labeled manual override control located within 10 feet of the actuator to allow chiller mechanics to control the valve during system startup and shutdown. This control shall generate a BAS alarm when in the override position, and shall display its value and status on the chiller graphic screen or screens.

F. A supply temperature sensor shall be installed downstream of any reheat coil.

G. A temperature sensor shall be installed in the cooling tower sump for any water cooled chiller plant for the purpose of resetting the condenser supply loop throttling range.

H. Temperature sensors shall be installed in any food service freezers or coolers that will alarm to the BAS when out of range. Each shall have a history trend, and all shall be displayed on a floor plan showing all related equipment.

I. A thermometer shall be installed adjacent to any BAS temperature sensor installed in a fluid pipe.

J. A pressure gauge shall be installed adjacent to any BAS pressure sensor installed in a fluid or gas pipe.
K. A pressure gauge shall be installed on the branch output of all pneumatic control devices.

1.3 TCS/SYSTEM INTEGRATION CONTRACTOR QUALIFICATIONS

A. General:

1. The Temperature Control Contractor/System Integrator shall have a successful history in the design and installation of NiagaraAx control systems with browser based wide area network connectivity and shall provide evidence of this history as a condition of acceptance of bid.

2. The Temperature Control Contractor/System Integrator shall have an office that is staffed with LONWORKS®, BACnet and Internet Protocol (IP) trained engineers and technicians fully capable of providing instruction and routine emergency maintenance service on all system components within 24 hours of notification.

1.4 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

1. WMU Western Michigan University
2. TCS Temperature Control System
3. NAC NiagaraAx Network Area Controller
4. IDC Interoperable Digital Controller
5. ASC Application Specific Controller
6. PCU Programmable Control Unit
7. IBC Interoperable BACnet Controller
8. GUI NiagaraAx Graphical User Interface
9. GDT Graphical Development Tool
10. POT Portable Operator's Terminal
11. DDC Direct Digital Controls
12. LAN Local Area Network
13. WAN Wide Area Network
14. PICS Product Interoperability Compliance Statement

1.5 DIVISION OF WORK

A. The TCS Contractor shall be responsible for all Interoperable Digital Controllers (IDC), Application Specific Controllers (ASC), NiagaraAx Network Area Controller(s) (NAC), control devices, control panels, IDC, ASC, PCU & NAC controller programming, controller programming software, controller input/output wiring, power wiring, interlock and safety wiring, and controller network wiring. The TCS Contractor shall also be responsible for the NiagaraAx Supervisor (GUI) graphical user interface software, development of all graphical screens, setup of
schedules, logs and alarms, LonWorks and/or BACnet network management, global supervisory control applications, system integration and coordination of all Niagara AX NAC's to the local and wide area network.

B. The following will be coordinated with WMU:

1. WMU shall be responsible for graphical standards and templates stored in the WMU Niagara AX Network Supervisor.

2. The TCS Contractor will utilize WMU graphic standards and templates available on the WMU Network Supervisor.

3. The TCS Contractor will develop and submit for approval all non standard system graphics for all specified mechanical and electrical systems, using animated objects to display all system variables and process valves, according to WMU standards.

4. Provide supervisory control strategies for mechanical and electrical systems to permit the global sequence of operations specified herein.

5. Coordinate BACnet addresses for IBC devices to ensure that there are no duplicate addresses on the network per the WMU BACnet address guidelines.

1.6 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

1.7 SOFTWARE LICENSE AGREEMENT

A. The software licensing must have no restrictions on which brand of Niagara AX NAC, Niagara AX Supervisor or System Programming tools can interact with the system. Station Compatibility must = ALL and the Tool Compatibility must = ALL. (“brand” accept.station.in=”*” accept.station.out=”*” accept.wb.out=”*” accept.wb.in=”*”)

B. The software and firmware licensing agreement shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

C. Software licensing for the Niagara AX NAC shall give the Owner the capability to control their system and determine which contractors can bid and engineer their system.
D. It shall be possible to insure the Owner can prevent unauthorized partners from accessing the system for engineering changes.

E. Software licensing shall have the freedom to individually manage authorized parties and independent parties.

F. WMU shall be provided any software required to program, setup, override, or manipulate any BAS devices installed on campus.

1.8 NETWORK ACCESS

A. WMU WAN / LAN Access

1. TCS Contractor’s must adhere to WMU OIT policy and requirements to obtain WMU WAN access.

1.9 SUBMITTAL

A. Electronic copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings. A complete written Sequence of Operation shall also be included with the submittal package.

B. Submittal shall also include a complete point list of all connected points to the DDC system.

C. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on electronic media. Drawings shall be provided as AutoCAD™ compatible files. Electronic copies of the ‘as-built’ drawings shall be provided in addition to the documents on electronic media.

1.10 QUALITY ASSURANCE

A. The manufacturer of the digital controllers shall provide documentation supporting compliance with ISO-9001 (Model for Quality Assurance in Design/Development, Production, Installation and Servicing). Product literature provided by the digital controller manufacturer shall contain the ISO-9001 Certification Mark from the applicable registrar.
1.11 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

Part 2 - PRODUCTS

2.1 GENERAL

A. The Temperature Control System (TCS) shall be comprised of a network of interoperable, stand-alone NiagaraAX NAC's, servers, operator workstations, NiagaraAX graphical user interface software, network devices, digital controllers and other devices as specified herein. All NiagaraAX products shall be revision 3.8 or higher.

B. The installed system shall provide secure password access to all features, functions and data contained in the overall TCS.

C. The following requirements apply to the NiagaraAX product selection:

Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers specified.
- Tridium Vykon AX
- Schneider-Electric I/A G3
- Honeywell WEBs AX or Comfort Point
- Johnson Controls Facility Explorer AX
- Or WMU approved alternate

D. The following requirements apply to the Interoperable Digital Controllers (IDC), Application Specific Controllers (ASC), and Programmable Control Units (PCU) product selection:

Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers specified.
- Tridium Vykon AX
- Schneider-Electric I/A (MNL-800 Controllers are NOT acceptable)
- Others to be considered as part of RFQ process
- Or WMU approved alternate

2.2 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

A. The intent of this guideline is to provide a peer-to-peer networked, stand-alone, distributed control system based on ANSI/ASHRAE Standard 135-1995 BACnet and/or LonTalk communication protocols with the capability to integrate SNMP, LonWorks, BACnet IP, BACnet MSTP, Modbus TCP/IP or Modbus RTU communication protocols in one open interoperable system. Adherence to industry standards including ANSI / ASHRAETM Standard 135-1995, BACnet
and LonMark™ to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet or MSTP. For each Modbus device supplier must provide a Registry of data points available on the system.

B. All components and controllers supplied under this contract shall be true “peer-to-peer” communicating devices. Components or controllers requiring “polling” by a host to pass data shall not be acceptable.

C. Use of gateway devices for communication at any level within the system shall not be acceptable without written permission from the Energy Systems Specialist.

D. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs.

E. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 180 seconds for network connected user interfaces.

2.3 NiagaraAX NETWORK AREA CONTROLLER (NAC)

A. The TCS contractor shall supply one or more NiagaraAX Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices provided under this section.

B. The NiagaraAX Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NiagaraAX NAC. It shall be capable of executing application control programs to provide:

- Calendar functions
- Scheduling
- Trending
- Alarm monitoring and routing
- Time synchronization
- Integration of LonWorks controller data, Modbus controller data and BACnet controller data
- Network Management functions for all LonWorks, BACnet or Modbus based devices

C. All NiagaraAX Network Area Controllers (NAC) shall include embedded Workbench.
2.4 INTEROPERABLE DIGITAL CONTROLLERS (ILC & IBC)

A. Application Specific Controller (ASC)

1. Each terminal unit shall have a LONWorks® or BACnet based DDC Application Specific Controller (ASC) designed to provide the specified sequences. The controller shall be LONMark® certified or BACnet ANSI/ASHRAE Standard 135-1995 compliant, and shall store all specific control sequences and program settings in non-volatile memory.

2. Each ASC shall perform all intended temperature control functions in a ‘standalone’ mode should the unit incur a loss of communications.

3. In the event of a power outage or controller reset, each ASC shall enter a preprogrammed state on power re-application. Upon application of power to the ASC, all control conditions will start from an ‘off’/’closed’ position or the default state. This state will be maintained for an automatically adjusted amount of time. Once this time delay has passed, the ASC control sequence shall resume according to current values.


5. All ASC’s shall be provided with a communications port to allow connection of any industry standard laptop PC and custom configuration tools. Program access via this communications port allows direct field modification of the configuration parameters.

6. It shall be the responsibility of the TCS to verify that VAV box controllers will physically fit into the VAV box controls enclosure, and that the controllers can register the expected minimum and maximum flow rates utilizing the flow probe provided by the VAV box manufacturer.

B. Programmable Control Units (PCU’S)

1. A LONWorks® or BACnet based DDC Programmable Control Unit (PCU) shall be provided where required to perform the sequence of operation. The PCU shall be fully configurable by configuration tool. The controller shall store all specific control sequences and program settings in non-volatile memory.

2. Each PCU shall perform all intended temperature control functions in a ‘standalone’ mode should the unit incur a loss of communications.

3. In the event of a power outage or controller reset, each PCU shall enter a preprogrammed state on power re-application. Upon application of power to the PCU, all control conditions will start from an ‘off’/’closed’ position or the default state. This state will be maintained for an automatically adjusted amount of time. Once this time delay has passed, the PCU control sequence shall resume according to current values.

5. All PCU’s shall be provided with a communications port to allow connection of any industry standard laptop PC and custom configuration tools. Program access via this communications port allows direct field modification of the configuration parameters.

2.5 INTEROPERABLE LONWORKS DIGITAL CONTROLLERS (ILC)

A. ILC controllers shall be microprocessor based Interoperable LonMark™ or LonWorks Controllers. Where possible, all Interoperable Digital Controllers shall bear the applicable LonMark™ interoperability logo on each product delivered.

B. Provide ILC’s and ancillary devices as herein specified, as indicated on the drawings, and as necessary to perform the sequences of operation.

C. Control shall be accomplished using LonMark™ based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, such as freely programmable controllers, the manufacturer must provide an XIF file for the device. Publicly available specifications for the Applications Programming Interface (API) must be provided. The TCS Contractor shall provide all programming and documentation necessary to set up and configure the supplied devices per the specified sequences of operation.

D. The TCS Contractor shall route the LonWorks network trunk to the Niagara AX Network Area Controller (NAC) as indicated on the riser diagram in the bid documents. Coordinate locations of the Niagara AX NAC to ensure that maximum network wiring distances, as specified by the LonWorks wiring guidelines, are not exceeded. All LonWorks and LonMark devices must be supplied using FTT-10A LonTalk communication transceivers.

E. The Niagara AX Network Area Controller (NAC) will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks based devices.

F. All ILCs shall be fully application programmable and shall at all times maintain their LONMARK certification, if so certified. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

G. It is the responsibility of the TCS Contractor to ensure that the proper Network Variable Inputs and Outputs (nvi and nvo) are provided in each ILC and are exposed for connection to them as required by the point charts. Refer to the software point charts for the required functionality (read-only, write-only, read-write) for each data point. Use of manufacturer-specific Network Variables shall not be permitted, unless software is provided to allow the use of them by any third-party network management tool.
H. All ILC’s shall be capable of being managed (upload, download, discovery, reload, bindings, etc.), by any Lon network management tool. ILC’s that can be managed only with LNS-based tools or plug-ins built exclusively for LNS, shall not be permitted.

I. The TCS Contractor shall provide two copies of the ILC programming tool and configuration tool, with documentation, to the owner. This tool shall NOT require IIS.

1. This tool shall allow the owner to fully program, configure, diagnose and otherwise manage the controller, without limitations.

2. The tool shall be of the latest revision currently in production release by the manufacturer.

3. The tool shall be licensed to the owner and shall not require annual license renewal fees.

4. The tool shall not be dependent on the LNS network management system in order to properly function and shall be capable of running as a stand-alone application on a Windows operating system. Use of LNS-based plug-ins for programming and configuration are not acceptable.

2.6 INTEROPERABLE BACnet CONTROLLER (IBC)

A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the ANSI/ASHRAE Standard 135-1995. IBCs shall be provided for Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-1995.

B. The IBCs shall communicate with the Niagara^AX NAC via an Ethernet connection at a baud rate of not less than 10 Mbps or via the RS485 connection at a baud rate of not less than 38 kbps.

C. Each IBC shall have a connection port within 12 feet of the device. If the IBC has no port, use a sensor for connection. The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.

D. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. All control sequences within or programmed
into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

E. The Division 15 contractor supplying the IBC’s shall provide documentation for each device, with the following information at a minimum:
   BACnet Device; MAC address, name, type and instance number
   BACnet Objects; name, type and instance number

F. It is the responsibility of the Division 15 contractor to ensure that the proper BACnet objects are provided in each IBC and are exposed for connection to them as required by the point charts, and that BACnet instance numbers are not duplicated campus wide.

G. The TCS Contractor shall provide two copies of the IBC programming tool and configuration tool, with documentation, to the owner. This tool shall NOT require IIS.

   1. This tool shall allow the owner to fully program, configure, diagnose and otherwise manage the controller, without limitations.

   2. The tool shall be of the latest revision currently in production release by the manufacturer.

   3. The tool shall be licensed to the owner and shall not require annual license renewal fees.

   4. The tool shall not be dependent on the BACnet network management system in order to properly function and shall be capable of running as a stand-alone application on a Windows operating system.

2.7 SPACE TEMPERATURE SENSORS

A. Space temperature sensors shall display the temperature when used to directly control any terminal unit.

B. Space temperature sensors connected to VAV controllers shall include temperature adjustment, and the option for set-points to be set locally or remotely.

C. Space temperature sensors connected to fan-powered-boxes or other terminal units with fans shall include temperature adjustment, and the option for set-points to be set locally or remotely. They shall also include fan control, and the option for that fan control to be local, remote, or automatic.

2.8 TEMPERATURE CONTROL PANELS

A. Furnish temperature control panels of code gauge steel for mounting all devices as shown. Panels shall conform to NEMA 1 standards, unless otherwise indicated.
B. If locking doors are used, lock cores shall use one of the following keys only CAT60, CAT102, CH751, 1289, 1344.

C. Control panels shall meet all requirements of UL508A and shall be so certified.

D. All external wiring shall be connected to terminal strips mounted within the panel.

E. Provide engraved phenolic nameplates identifying controlled equipment mounted on the face of control panels.

F. A complete set of ‘as-built’ control drawings (relating to the controls within that panel) shall be furnished within each control panel.

2.9 VARIABLE FREQUENCY DRIVES

A. Furnish Variable Frequency Drives (VFD) for installation by the electrical contractor (Div. 16). Drives shall be factory equipped with a LonTalk FTT-10A communications interface and the XIF file for the drive shall be provided.

B. Acceptable VFD manufacturers are Danfoss and ABB.

2.10 THERMOMETERS AND GAUGES

A. Thermometer ranges shall be scaled so that normal operating temperatures are in the middle 40% of the thermometer’s range, and so that minimum and maximum operating temperatures are not outside of the thermometer’s range.

B. Pressure gauge ranges shall be scaled so that normal operating pressures are in the middle 40% of the gauge’s range, and so that minimum and maximum operating pressures are not outside of the gauge’s range.

Part 3 - EXECUTION

3.1 INSTALLATION

A. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the temperature control system manufacturer or its exclusive factory authorized installing contracting field office (representative). Supervision, calibration and checkout of the system shall be by the employees of the local exclusive factory authorized temperature control contracting field office (branch or representative).

B. Install system and materials in accordance with manufacturer’s instructions, and as detailed on the project drawing set.

C. Drawings of temperature control systems are diagrammatic only and any apparatus not shown, such as relays, accessories, etc., but required to make the
system operative to the complete satisfaction of the Engineer and Owner shall be furnished and installed without additional cost.

D. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the TCS Contractor in accordance with these specifications.

E. Equipment furnished by the HVAC Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the TCS Contractor.

F. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

G. All electrical control wiring and power wiring to the control panels shall be the responsibility of the TCS Contractor.

H. The electrical contractor (Div. 16) shall furnish all power wiring to electrical starters and motors.

I. All wiring shall be in accordance with the Project Electrical Specifications (Division 16), the National Electrical Code and any applicable local codes. All TCS wiring shall be installed in the conduit types specified in the Project Electrical Specifications (Division 16) unless otherwise allowed by the National Electrical Code or applicable local codes. Where TCS plenum rated cable wiring is allowed, it shall be run parallel to or at right angles to the structure, properly supported and installed in a neat and workmanlike manner.

3.2 WIRING

A. General Requirements

1. Install low voltage power and LON and LAN communication trunks in conduit in the following locations regardless of local building code allowances otherwise.
   - Mechanical rooms.
   - Electrical rooms.
   - Vertical risers (exception: fire rated continuous closet like a telephone closet).
   - Open Areas where the wiring will be exposed to view or tampering.

2. Splices
   Splices in shielded cables shall consist of terminations and the use of shielded cable couplers which maintain the integrity of the shielding. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties as specified herein. Splices are not permitted in the FMS LAN or LON communication cables.
   Follow manufacturer suggested procedures for proper slicing.
3. Conceal conduit within finished shafts, ceilings and wall as required. Install exposed conduit parallel with or at right angles to the building walls.

4. Tag all equipment, panels, cables, conduits, junction boxes, etc., as called out in the “Identification” section of this specification and as shown on the drawings.

5. Perform installation of all devices in the manner specified by each manufacturer.

6. Where Class 2 wires are in concealed and accessible locations including ceiling return air plenums, approved cables not in raceway may be used provided that:
   Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
   All cables shall be UL listed for application, i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose.

7. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage may not be used for low voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

8. Where Class 2 wiring is run exposed, wiring to be run parallel along a surface or perpendicular to it, and neatly tied at 3m intervals.

9. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

10. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. LON NETWORK REQUIREMENTS

1. Wired network communication shall utilize approved Lon cable as indicated on the drawings. No substitutions will be allowed.

2. Communication conduits shall not be installed closer than 2m from high power transformers or run parallel within six feet of electrical high power cables. Care shall be taken to route the cable as far from interference generating devices as possible.

3. Lon network wiring shall be installed as shown on riser diagram.

4. There shall be no power wiring, in excess of 30 VAC rms, run in conduit with communications wiring.

5. Recommended Lon wiring guidelines shall be followed for double-terminated bus topology, with repeaters provided as required, based on wiring distance
and device quantity configuration. In no case shall the total network wiring distance from any NAC to the last Lon device on the network exceed 1,400 meters, with a maximum stub length of 3 meters.

6. All Lon wiring shall be run in a daisy chain configuration. Star configurations are not acceptable.

7. Each NAC used in one building or complex shall use different colored Lon wire.

C. Identification

1. Wire Tags
   a. All multi-conductor cables, including those for all I/O devices, in all pull boxes and terminal strip cabinets shall be uniquely tagged at both ends to identify what device and/or contact point is at the other end of the wire. Keep a catalog of wire identification for submittal to Western Michigan University at the project’s completion.
   b. Provide wire Tags as per Division 16.

2. Conduit Tags
   a. Provide tagging or labeling of conduit so that it is always readily observable which conduit was installed or used in implementation of this Work.

3. Miscellaneous Equipment Identification
   a. Screwed-on, engraved blue laminoid sheet with white lettering on all control panels and remote processing panels. Lettering sizes subject to approval.
   b. Inscription, subject to review and acceptance, indicating equipment, system numbers, functions and switches. For panel interior wiring, input/output modules, local control panel device identification.

F. A duplex receptacle must be located within six feet of any control cabinet that contains a programmable device.

G. All DDC wall mounted thermostats/sensors shall have LAN access from the thermostat/sensor.

3.3 NETWORK INFRASTRUCTURE AND ADDRESSING

A. WMU’s Energy System Specialist shall assign IP addresses for all Ethernet connected controllers associated with the BAS.

B. The router IP address and subnet mask settings shall be provided by WMU’s Energy System Specialist.

C. BACnet network numbers shall not be duplicated. Control contractors shall use WMU’s BACnet address guidelines for instance and network number addressing. Control contractor shall be responsible to correct any network disruption caused by BACnet instance number duplication or incorrect configuration.
3.4 PROGRAMMING

A. Niagara\textsuperscript{AX} Programming

1. The Niagara\textsuperscript{AX} Graphical Development Tool (GDT) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the Niagara\textsuperscript{AX} GDT shall be through password access as assigned by the system administrator.

2. The Niagara\textsuperscript{AX} GDT shall be available in two versions; a thick-client version licensed to the computing platform on which it is installed and a thin-client version, capable of providing the complete set of engineering functions through a standard Web Browser. Programming and development tools not capable of providing all engineering and application development functions with a standard Web Browser are not acceptable.

3. Niagara stations shall be named according to the building name and shall not include WMU in the name. Each name shall begin with a capital letter; this includes buildings which use more than one word. For example, the station name for Waldo Stadium would be “WaldoStadium”.

4. If data must be passed from one LonWorks device to another, then the data shall be linked (bound) directly from Lon shadow object to Lon shadow object without being passed through other control objects in the NAC so that data will continue to flow if the NAC is off-line.

5. Control programs shall use WMU as-built room numbers to refer to all spaces. Construction room numbers are not to be used if they differ from the as-built room numbers.

6. Spaces that use VAV boxes shall be programmed such that all VAV boxes supplied by a particular AHU can be driven to maximum flow with a single command. Additionally this single command shall be activated if the variable frequency drive (VFD) on the supply fan is placed in “hand” or “bypass”.

7. Hydronic heating systems shall be programmed such that all related heating valves can be overridden open with a single command for balancing purposes.

8. Chilled water systems shall be programmed such that all related cooling valves can be overridden open with a single command for balancing purposes.

9. Control programs shall be configured such that automatic control will still function if equipment such as fans and pumps are put in hand. Control enable signals shall not rely on schedules or start commands, but shall instead rely on equipment status. For example, the discharge air temperature control of an air-handling unit shall be enabled based on supply fan status, not the BAS schedule or start signal to the unit.

10. Return fans shall be interlocked with supply fans so that the return fan will not run in automatic if the supply fan is not running unless a sequence specifically requires it.
11. Maintenance Time Reminders (MTR) shall not be specified unless the design professionals provide the control contractor with specific time intervals for each piece of equipment that is to have an MTR. These time intervals shall be in accordance with the equipment O&M recommendations.

12. TAC IA sequenced loops are not to be used for air handler discharge air temperature control.

13. In those buildings with VAV boxes, the actual VAV air flows shall be totaled up. There shall be total air flows for each air handling unit, each floor, and the building.

3.5 GLOBAL COMMAND AND CONTROL

A. The control contractor is responsible for making all of the links required to pass the global signals listed in this section and for programming the proper local default/fallback values for those signals.

B. Occupied heating, occupied cooling, standby heating, standby cooling, unoccupied heating, unoccupied cooling, heating offset, and AHU space temp set points are all sent from the BAS server to the local control devices. Proper defaults must be used in local control devices. Current values for these set points can be viewed at the WMU BAS website.

C. Equipment is rotated every Monday morning at 7:00am. A master schedule for this event is located in the BAS server. If building equipment must rotate, a slave schedule shall be placed in the building’s NAC, receiving its schedule command from the master schedule. It shall be possible to override the rotate signal at the local equipment level.

D. Master time of day schedules shall reside on the BAS server to allow off-site editing of the schedule. Slave schedules shall be located in the NAC acting as defaults, receiving signals from their respective master schedules.

E. Time of day schedules shall be organized according to room use to facilitate holiday scheduling for different types of spaces. Master holiday schedules are located in the BAS server and are divided into at least two types, OFFICE and CLASSROOM.

F. A roof heat-tape (or ice melt) enable signal is sent globally from the BAS server and shall be used on those projects that include heat-tape or snow-melt. It originates from several moisture sensors located on campus. Outside temperatures must be below 35°F and at least two moisture sensors must indicate ON before the global snow-melt, heat-tape, or ice melt signal is enabled. An off delay is programmed in at the building level to allow different off delay times for each building. Overrides for any DO (digital output), and the amount of time delay for the building, shall both be accessible from the BAS ice melt graphic screen. If there is a communications loss between the server and the local heat-tape controller the program shall default to a local outside temperature thermostat and the heat-tape shall be ON if the outside temperature is below 35°F.
G. A chiller alarm disable command is sent to all devices controlling chillers for the purpose of disabling chiller alarms during the winter season.

H. Each building shall receive a global signal to disable the occupancy sensors for the HAVC while the building schedule is in the unoccupied mode. This will prevent the HVAC system from starting based on occupancy sensor commands when the building is scheduled as unoccupied.

I. A global site lighting signal is sent from the BAS server to turn lights on/off.

3.6 GRAPHICAL INTERFACE

A. Graphics shall be accessible from a standard web browser.

B. All equipment controlled or monitored by the BAS shall be graphically represented.

C. Equipment Views: A maximum of 40 points will be provided in a single status display screen. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, shall be setup such that an operator, by right-clicking the data object or graphic, shall be able to command a digital value, or modify an analog value.

D. All graphics shall reside on the Niagara AX Enterprise Server.

E. Graphics of floor plans shall include WMU as-built room numbers for all spaces. Construction room numbers are not to be used if they differ from the as-built room numbers.

F. Graphics of floor plans shall be colored to indicate which spaces are supplied by specific air-handlers. Colors shall be standardized according to the following chart:

<table>
<thead>
<tr>
<th>Floor Color</th>
<th>AHU #</th>
<th>(RGB) &gt;</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray</td>
<td>no AHU</td>
<td>191 191</td>
<td>191</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light blue</td>
<td>AHU-1</td>
<td>139 230</td>
<td>255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pale Yellow</td>
<td>AHU-2</td>
<td>255 255</td>
<td>153</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark Green</td>
<td>AHU-3</td>
<td>0 255</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>AHU-4</td>
<td>255 255</td>
<td>255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>AHU-5</td>
<td>255 151</td>
<td>102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark Blue</td>
<td>AHU-6</td>
<td>20 111</td>
<td>194</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violet</td>
<td>AHU-7</td>
<td>116 76</td>
<td>190</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red</td>
<td>AHU-8</td>
<td>255 48</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bright Yellow</td>
<td>AHU-9</td>
<td>255 237</td>
<td>18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Green</td>
<td>AHU-10</td>
<td>109 182</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If a project contains more than 10 air handlers the controls contractor shall seek guidance from WMU personnel to establish additional colors.

G. Fan status shall be displayed using a Boolean graphic that displays a spinning fan wheel when the status is ON and a stationary fan wheel when the status is OFF.
Pump status graphics shall be displayed in a like manner using a pump impeller in a pump. If a fan or pump has no DI (digital input) to display the status a NS (no status) shall be placed on the fan or pump icon on the graphics screen to indicate there is no motion ON/OFF status.

H. DO (digital outputs) shall be displayed using a Boolean graphic that displays a green switch ON when the status is ON and a red switch OFF when the status is OFF. These switch graphics shall not be used for anything other than digital outputs.

I. Heating and cooling coils shall be displayed using a Boolean graphic that displays a color change when the status is ON and an off-white coil when the status is OFF. Text status shall accompany this color change. See the WMU BAS Control Center for more details.

J. Temperatures and fluid pressures shall be displayed to one decimal place. Relative humidity, control signal output percentages, and air flows shall be displayed to zero decimal places. Static pressures shall be displayed to two decimal places.

K. The BAS Network Diagram graphics pages shall be updated whenever new control devices are added to the BAS network.

L. Every building shall have a graphic screen that lists all of the BAS alarms for that building and the status of each alarm. VAV and VFD alarms will not be listed on this primary alarm screen. Fan and pump status alarms shall be listed. These alarm graphic screens shall be configured such that when a point is in alarm the text on the graphic for that point shall flash red with the current point value. These alarm screens shall be arranged in a table format with the alarm points clearly labeled as to what they are. The text point identifying the equipment shall also be a link to the graphic page for that equipment.

M. Transfer links from one screen to another shall be configured such that clicking a link will not cause a new window to pop up.

N. Timed overrides shall be displayed on graphics screens for all equipment such that equipment can be manually manipulated. This includes fans, pumps, dampers, and valves.

O. Fluid piping graphics shall include dynamically linked animated arrows that indicate flow by showing moving arrows when flow is true, and no arrows when flow is false. The arrows must show the correct flow direction and accurately show the sections of pipe that have flow.

3.7 SOFTWARE AND DOCUMENTATION

A. The control contractor shall provide WMU with all software and cabling required to access and/or program any and all programmable devices installed on a job. Software provided must be the latest version available. The contractor is not required to supply this software if WMU already has it. However, updated revisions shall be provided to WMU if they are more recent than those owned by WMU.
B. The control contractor shall provide WMU with at least one electronic copy of all programming manuals relevant to any and all programmable devices installed on a job. This manual shall be complete and provide instruction on how to program said devices.

C. As-built control drawings shall indicate the location of all control system components.

D. As-built control drawings shall indicate the proper device layout sequence of all control devices on a daisy chain communications bus.

3.8 SEQUENCES

The sequences listed in this document are typical of how WMU prefers to control its equipment. These sequences were developed for both energy management and occupant comfort. The control system shall be capable of implementing these sequences if it is to be accepted. These sequences should be strictly adhered to wherever possible. Exceptions can only be made in those cases where special design considerations prevent the use of one or more of these sequences. WMU must be consulted before a deviation is made.

Program each Niagara® NAC, IDC, ASC, PCU, etc, to perform the sequences of operation printed on the control drawings. Provide all necessary hardware on each piece of equipment in order for the equipment to perform the specified sequences.

TCS Contractor shall be responsible for all control wiring connections, auxiliary devices and control wiring diagrams to complete the control system and attain the described sequence of operation.

A. Terminal Unit Control Sequences

1. Variable Air Volume Box Control With Occupancy Sensor(s):

   a. Unoccupied mode (building occupancy schedule off, occupancy sensor off): The VAV damper and heating valve(s) (if applicable) will be closed and the airflow set point shall be 0 CFM. If the space temperature rises to the unoccupied cooling set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV CFM, up to maximum airflow, to maintain space temperature at set point. When space temperature falls sufficiently below the unoccupied cooling set point the VAV controller shall call for 0 CFM airflow. If the space temperature falls to the unoccupied heating set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV damper to maintain airflow at the minimum/reheat minimum CFM set point. The heating valve(s) shall modulate to maintain the space temperature at set point. When space temperature rises sufficiently above the unoccupied heating set point the VAV controller shall call for 0 CFM airflow and the heating valve(s) shall close. When a person enters the
space the occupancy sensor shall not place the VAV in the occupied mode. An override push button shall be located on the thermostat, and shall provide a one hour occupied override.

b. Standby mode (building occupancy schedule on, occupancy sensor off): The VAV damper and heating valve(s) (if applicable) will be closed and the airflow set point shall be 0 CFM. If the space temperature rises to the standby cooling set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV CFM, up to maximum airflow, to maintain space temperature at set point. When space temperature falls sufficiently below the standby cooling set point the VAV controller shall call for 0 CFM airflow. If the space temperature falls to the standby heating set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV damper to maintain airflow at the minimum/reheat minimum CFM set point. The heating valve(s) shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the standby heating set point the VAV controller shall call for 0 CFM airflow and the heating valve(s) shall close. When a person enters the space the occupancy sensor shall place the VAV in the occupied mode.

c. Occupied mode (building occupancy schedule on, occupancy sensor on): The VAV damper shall modulate to maintain airflow at the minimum CFM set point and heating valve(s) (if applicable) will be closed. The AHU should be running as a result of an airflow set-point greater than zero. If the space temperature rises to the occupied cooling set point the VAV controller shall call for additional airflow, up to maximum airflow, and modulate the VAV CFM to maintain space temperature at set point. When space temperature falls sufficiently below the occupied cooling set point the VAV controller shall return to minimum airflow. If the space temperature falls to the occupied heating set point the VAV controller shall modulate the VAV damper to maintain airflow at the reheat minimum CFM set point. The heating valve(s) shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the occupied heating set point the VAV controller shall return to minimum airflow and the heating valve(s) shall close.

2. Variable Air Volume Box Control Without Occupancy Sensors:

a. Unoccupied mode (space occupancy schedule off): The VAV damper and heating valve(s) (if applicable) will be closed and the airflow set point shall be 0 CFM. If the space temperature rises to the unoccupied cooling set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV CFM, up to maximum airflow, to maintain space temperature at set point. When space temperature falls sufficiently below the unoccupied cooling set point the VAV controller shall call for 0 CFM airflow. If the space temperature falls to the unoccupied heating set point the VAV controller shall call for airflow (which will command the AHU on) and modulate the VAV damper to maintain airflow at the minimum/reheat minimum CFM set point. The
heating valve(s) shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the unoccupied heating set point the VAV controller shall call for 0 CFM airflow and the heating valve(s) shall close. An override push button shall be located on the thermostat, and shall provide a one hour occupied override.

b. Occupied mode (space occupancy schedule on): The VAV damper shall modulate to maintain airflow at the minimum CFM set point and heating valve(s) (if applicable) will be closed. The AHU should be running as a result of an airflow set-point greater than zero. If the space temperature rises to the occupied cooling set point the VAV controller shall call for additional airflow, up to maximum airflow, and modulate the VAV CFM to maintain space temperature at set point. When space temperature falls sufficiently below the occupied cooling set point the VAV controller shall return to minimum airflow. If the space temperature falls to the occupied heating set point the VAV controller shall modulate the VAV damper to maintain airflow at the reheat minimum CFM set point. The heating valve(s) shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the occupied heating set point the VAV controller shall return to minimum airflow and the heating valve(s) shall close.

3. All Variable Air Volume Boxes:

a. Warm-up mode: If a warm-up mode is desired it shall be initiated by changing the AHU discharge air temperature set point to 100 degrees F (adjustable). Regardless of whether or not a warm-up sequence is programmed into the AHU, if the AHU discharge temperature rises above 73 degrees F (adjustable) the VAVs supplied by that AHU shall be placed in a reverse acting mode while the outside air temperature is below 55 degrees F (adjustable). If the outside air temperature is above 55 degrees F (adjustable) the VAV boxes shall not be placed in a reverse acting mode at any time.

4. Fan Coil Unit Control With Occupancy Sensor(s):

a. Unoccupied mode (building occupancy schedule off, occupancy sensor off): The fan-coil unit heating and cooling valve(s) will be closed and the fan shall be off. If the space temperature rises to the unoccupied cooling set point the fan shall start and the cooling valve shall modulate to maintain space temperature at set point. When space temperature falls sufficiently below the unoccupied cooling set point the fan shall stop and the cooling valve shall close. If the space temperature falls to the unoccupied heating set point the fan shall start and heating valve shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the unoccupied heating set point the fan shall stop and the heating valve shall close. When a person enters the space the occupancy sensor shall not place the FCU in the occupied mode. An override push button shall be located on the thermostat, and shall provide a one hour occupied override.
b. Standby mode (building occupancy schedule on, occupancy sensor off): The fan-coil unit heating and cooling valve(s) will be closed and the fan shall be off. If the space temperature rises to the standby cooling set point the fan shall start and the cooling valve shall modulate to maintain space temperature at set point. When space temperature falls sufficiently below the standby cooling set point the fan shall stop and the cooling valve shall close. If the space temperature falls to the standby heating set point the fan shall start and heating valve shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the standby heating set point the fan shall stop and the heating valve shall close. When a person enters the space the occupancy sensor shall place the FCU in the occupied mode.

c. Occupied mode (building occupancy schedule on, occupancy sensor on): The fan-coil unit shall be off and the heating and cooling valves shall be closed. If the space temperature rises to the occupied cooling set point the fan shall start and the cooling valve shall modulate to maintain space temperature at set point. When space temperature falls sufficiently below the occupied cooling set point the fan shall stop and the cooling valve shall close. If the space temperature falls to the occupied heating set point the fan shall start and the heating valve shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the occupied heating set point the fan shall stop and the heating valve shall close.

5. Fan Coil Unit Control Without Occupancy Sensor(s):

a. Unoccupied mode (building occupancy schedule off): The fan-coil unit heating and cooling valve(s) will be closed and the fan shall be off. If the space temperature rises to the unoccupied cooling set point the fan shall start and the cooling valve shall modulate to maintain space temperature at set point. When space temperature falls sufficiently below the unoccupied cooling set point the fan shall stop and the cooling valve shall close. If the space temperature falls to the unoccupied heating set point the fan shall start and heating valve shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the unoccupied heating set point the fan shall stop and the heating valve shall close. An override push button shall be located on the thermostat, and shall provide a one hour occupied override.

b. Occupied mode (building occupancy schedule on): The fan-coil unit shall be off and the heating and cooling valves shall be closed. If the space temperature rises to the occupied cooling set point the fan shall start and the cooling valve shall modulate to maintain space temperature at set point. When space temperature falls sufficiently below the occupied cooling set point the fan shall stop and the cooling valve shall close. If the space temperature falls to the occupied heating set point the fan shall start and the heating valve shall modulate to maintain space temperature at set point. When space temperature rises sufficiently above the occupied heating set point the fan shall stop and the heating valve shall close.
B. Air Handling Unit (AHU) Control Sequences

1. Air Handling Unit Control - All Air Handlers:
   a. When the supply fan is off, the outside air dampers and cooling valve(s) shall all be closed. The heating valve(s) shall modulate to prevent the lowest temperature in the AHU from going below 50°F.
   b. If an AHU has a chilled water coil, and the chiller status (the chiller that supplies that particular AHU) is off for more than two hours, the outside dampers shall not go to minimum position, but instead shall open to provide outside ventilation.
   c. If there is a diagnostic error on any of the sensors that affect control of an air handler, the supply fan (and return fan if applicable) will shut down and a BAS alarm shall be generated.
   d. If an AHU has any pneumatically controlled, normally open heat, a loss of main control air pressure (pressure below 15 psig) will shut the AHU down to prevent overheating of the space. A heating night setback call shall override this function and run the fan(s).
   e. On all AHUs with steam supplied face and bypass heating coils the steam valve shall remain fully open at outside temperatures below 45°F (adjustable) and the face/bypass dampers shall modulate to control temperature. At outside temperatures above 45°F the face/bypass dampers shall remain in the bypass condition (yes, fully closed to the coil) and the steam valve shall modulate to control temperature. This sequence replaces the heating portion of B-1-a.

2. Air Handling Unit Control - Single Discharge Units:
   a. An air handling unit with a heating coil, mixed air dampers, and cooling coil (or any combination) shall modulate them in sequence such that the heating coil and cooling coil never open together unless it is for a dehumidification sequence. The mixing dampers shall modulate in sequence between the heating and cooling coils so that on a call for mechanical heat, the outside dampers shall be at minimum position. At outside temperatures below 60 degrees (adjustable), and on a call for cooling, the outside dampers shall modulate 100% open before the mechanical cooling modulates open (chilled water), or is sequenced on (DX). At outside temperatures above 60 degrees the outside dampers shall be at minimum position.

3. Air Handling Unit Control - Single Zone Units:
   a. If an AHU supplies only one temperature zone, with only one space temperature sensor, an economizer space temperature set point shall also be part of the control program. At outside temperatures below 60 degrees (adjustable) the outside dampers shall modulate as needed to maintain the space temperature at the global AHU space temp set point. At outside temperatures above 60 degrees the outside dampers shall be at minimum position.
4. Variable Speed Air Handlers for Variable Volume Systems:
   a. An AHU shall start if there is airflow demand from any one VAV box supplied by that air handler.
   b. All VAVs supplied by a particular AHU shall be defined as a zone for the purposes of this sequence. All zone space temperatures shall be averaged. A reverse acting PID loop shall be configured such that its input shall be the average zone space temperature and its set point shall be the AHU space temp set point. The loop output shall be used as the AHU discharge temperature set point and shall be limited between 55 and 100 degrees F (adjustable). This sequence is designed to use the AHU temperature control to maintain most spaces in the zone at or close to the AHU space temp set point. This would, ideally, position most VAVs at minimum CFM with no heat running.
   c. Occupancy schedules shall enable the VAV box controller (no occupancy sensors), not the air handler. When occupancy sensors are used the occupancy schedule is used to change set points from unoccupied to standby.
   d. The AHU supply static pressure set point shall be reset dynamically based on the actual demand of the VAV system. The goal is to use the lowest possible static pressure in the system that will still allow the VAV boxes to meet their current airflow demand.

5. CO2 Control Sequences
   a. For VAV systems: As the space CO2 level rises to 1000 PPM (parts per million) the VAV box for that space shall modulate open, up to its maximum airflow, to maintain the CO2 level at 1000 PPM or less. The AHU shall monitor all CO2 controlled spaces for the maximum CO2 level. As the maximum CO2 level rises to 1100 PPM the outside air dampers on the AHU shall modulate open to maintain that CO2 level at 1100 PPM or lower. The mixed air low limit control shall be able to override this damper signal to prevent freeze stat trips.
   b. For single space systems: As the space CO2 level rises the outside air dampers on the AHU shall modulate open to maintain that CO2 level along a reset schedule (400 PPM = minimum OA dampers, 1100 PPM = 100% OA dampers). The mixed air low limit control shall be able to override this damper signal to prevent freeze stat trips.

C. Heating Water Control Sequences
   1. All Reheat Systems:
      a. Reheat heating water pumps shall start based on demand from the system. The BAS shall monitor control signals to all reheat valves in the system to determine the demand for heat. If there is no demand the pumps shall be off.

D. Chiller Control Sequences
   2. All Chillers:
a. If the outside temperature is above 55 degrees (adjustable), and at least one AHU supplied by a chiller plant is running, the chiller system shall be enabled. If any one of these is not true the chiller system shall be disabled.
b. If there is a diagnostic error in any of the sensors that affect control of a chiller plant (in other words, the loss of this sensor would be harmful to chiller operations), the chiller system will shut down and a BAS alarm shall be generated.
c. Once the control system senses that a chilled water primary pump is running, the chilled water secondary pump(s) shall start. In addition, if there are multiple chilled water zones, at least one AHU fed by any given zone pump must be running before that zone pump is allowed to run. If there are parallel pumps, the lead pump shall start.

3. Water Cooled Chillers:

a. Once the control system senses that a condenser water pump is running, the control system will modulate the cooling tower valve and cooling tower fans (VFD) in sequence to maintain the condenser water supply temperature at set point. The cooling tower valve shall fail open to the cooling tower, and closed to the bypass.
b. In addition to the condenser water supply and return sensors, a cooling tower sump temperature sensor shall be provided. The cooling tower sump temperature shall reset the condenser water supply temperature control loop throttling range. The initial reset schedule shall be as follows: 60 degree F sump temp = 80 degree TR, 85 degree sump = 20 degree TR. This schedule shall be fine-tuned after chiller startup.

E. Miscellaneous Control Sequences

1. "No-Freeze" Program: If the outside temperature is below 32 degrees and any particular air handler that has a chilled water coil has a mixed air temperature below 40 degrees, the chilled water pumps that feed that AHU will start and the chilled water valve on the affected air handler will open to move water through the chilled water coil to prevent freezing. A BAS alarm shall also be generated for that AHU. This control program does not negate the need for hard-wired low-limit thermostats for freeze protection.

2. Parallel Pumps: If the lead pump fails, the lag pump should start in its place. The lead-lag alternates every Monday at 7:00 AM and the command is sent from the Niagara Supervisor.

3. Variable Speed Pumps: The control system shall control the speed of the frequency drive pump(s) to maintain differential pressure on the system at set point. If the pressure cannot be maintained with one pump, a second pump shall start (if applicable), and then a third pump if necessary, etc. If the lead pump fails, the lag pump should start in its place.
3.9 SYSTEM SECURITY

A. Western Michigan University staff shall be in charge of all BAS system security and the WMU Energy Systems Specialist shall be the system administrator.

B. A temporary user account and password shall be provided to the TCS Contractor by WMU to be used as the administrator account during initial installation of each NAC. Each TCS Contractor technician shall create a user account for themselves using the temporary admin account. WMU will then change the admin account.

C. Strong passwords shall be required.

3.10 ALARMS

A. Alarms shall be routed to the WMU BAS server. Alarms are divided into priorities from 1 to 255, 1 being the highest priority. The WMU BAS Control Center shall be consulted about specific alarm class assignment and routing.

B. All fans and pumps, which have both digital input and digital output points, shall be alarmed. The alarm shall be generated whenever the input and output values do not match. The time delay on these alarms shall be 20 minutes for fans and 10 minutes for pumps unless there is reason for a shorter delay.

C. Alarm text messages shall be descriptive and contain the building name and equipment type and number from which the alarm was generated. The alarm message shall also contain the room number where the equipment is located. Messages shall not contain any unnecessary characters.

D. Those heating systems that use parallel pumps shall have a non-paged status alarm on each pump as well as a paged alarm if both pumps fail. Heating pumps without a backup pump shall send a BAS alarm to the on-call pager whenever that pump fails and the outside air temperature is less than 50°F.

3.11 TRENDING

A. A trend shall be created for every networked variable frequency drive (VFD) on the “drive energy” point. This trend shall be located on the BAS server, shall take a sample every 60 minutes and archive the samples.

3.12 TRAINING

A. On-site control training shall be held for every building system that is connected to the BAS. This training shall be broken down by system, such as air-handling system, heating water system, cooling system, etc. Very small systems can be covered as a group in one training session. The control contractor shall cover all aspects of the control system for each system, describing the type and location of each controller, and covering the entire control program for each system in detail. If the contractor requires a formal space at WMU with special needs such
as projection equipment they must arrange this with the project manager prior to training. Training sessions shall not exceed 2 hours in length. If more than 2 hours is required to cover the entire building or project then multiple training sessions are required.

3.13 WARRANTY

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of at least one year from the time of system acceptance.

B. Within this period, upon notice by the Owner, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by the TCS Contractor at no expense to the Owner.

3.14 START-UP AND TESTING

A. It is the responsibility of the TCS Contractor to ensure the proper installation and performance of the Lon, BACnet or Modbus networks and to ensure the networks and attached devices are functioning properly. Once all devices are installed, programmed, configured and powered, all IDC’s supplied by the TCS Contractor shall be checked for proper communication, network bindings, and network traffic to ensure proper performance. The TCS Contractor shall correct any devices or performance found to be defective.

B. The TCS contractor shall reconfigure nodes as necessary to maintain traffic to no more than 50% of channel bandwidth capacity.

3.15 WARRANTY ACCESS

A. The Owner shall grant to the TCS Contractor, reasonable access to the TCS during the warranty period.

3.16 ACCEPTANCE TESTING

A. The TCS Contractor shall verify that all IDC’s are ready for operation. This inspection shall verify that the following items have been properly installed.

- Network connection.
- Power connection.
- Proper power supply voltage and type.
- Electrical installation conforms to local code authorities.
- Valves (normally open or closed).
- Fail safe devices are equipped with spring return operators.
- Device or control unit in a standalone mode accomplishes the following:
Operate smoothly throughout entire control range without binding or cogg.
Sensors have been calibrated to specifications.
Differential pressure transmitters have been zero and span adjusted.
With application code loaded, execute specific control loops effectively without hunting or hysteresis.
Point to point check of all digital I/O for continuity and correct execution of the functional operation.

B. Submit an Inspection Log, which enumerates the above in a check list form for all IDC’s. Indicate corrective action for non-conforming or defective products and/or product installations.

C. The TCS Contractor shall perform all necessary calibration, testing and debugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.

D. The TCS Contractor shall perform tests to verify proper performance of ALL networks, controllers, components, sequences of operation, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

E. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner’s Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner’s Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

F. System Acceptance: Satisfactory completion is when the Temperature Control sub-contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner’s Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

G. In conjunction with the work of other trades, thoroughly test all equipment and systems in a dynamic mode simulating all operating sequences including safety shutdown and emergency fire mode.