

ENERGY MANAGEMENT, BUILDING AUTOMATION SYSTEMS

Primary Purpose: In keeping with the section entitled *HVAC Systems* within these *General Guidelines* the primary purpose of a building automation system is:

- To maintain comfort and health of occupants, facilitating productivity and performance.
- To provide reliable environmental control to support research activities.

Guiding Principles: As stated in the *HVAC Section* within these *General Guidelines*, guiding principles for control system design shall be as follows:

- **Quality:** Provide systems/components of high quality. Typically referred to as “institutional quality” as opposed to “commercial quality”.
- **Reliability:** Provide systems that operate properly with minimal service interruptions.
- **Maintainability:** Provide systems that require minimal service and that facilitate convenient service when required.
- **Operability:** Provide systems that are as intuitive and easy to operate as possible while providing required functionality.
- **Flexibility:** Maintain options for potential future changes to spaces served within appropriate limits.
- **Sustainability:** Provide environmentally responsible designs with focus on energy efficiency and conservation.

Compliance: Energy Management/BAS systems shall be in compliance with all applicable codes and standards including:

- *ASHRAE 62.1 – Standard for Ventilation and Indoor Air Quality*
- *ASHRAE 90.1 – Energy Standard for Buildings*
- *ASHRAE 55 – Thermal Environmental Conditions for Human Occupancy*
- *ASHRAE Guideline GPC 36 – Best of Class Control Sequences for Air Systems*

Design Conditions: Design conditions for indoor and outdoor air for general occupied spaces shall be as presented in the *HVAC Systems* section within these *General Guidelines*. Design conditions for research laboratories shall comply with applicable codes and standards in addition to

requirements presented in the *Laboratory Ventilation* section within these *General Guidelines*. Design conditions for Animal Facilities shall comply with requirements of *AAALAC Guide for the Care and Use of Laboratory Animals* as well as the *Animal Rooms* section within these *General Guidelines*. Design conditions for other space types shall conform to applicable codes and standards in addition to specific application requirements.

Direct Digital Controls: A large percentage of the HVAC systems within campus buildings are served by direct digital control (DDC) building automation systems (BAS) with remote monitoring and control capability. Each system communicates with the central control station located within the Physical Plant Service Building (PPSB) through the campus Ethernet data communications system. At the control station each manufacturer’s control system(s) has a dedicated “host” computer or “head end” unit. The capabilities of each host computer include the following: monitoring, alarming/paging, trending, password management, programming of stand-alone controllers as well as storage of the configuration/programming of each stand-alone controller.

BAS Integration: Integration of the BAS for HVAC systems with other building automation systems such as fire alarm, card access, security, lighting, refrigerant detection and elevator systems is allowed, but only to a limited degree. Systems shall have independent control panels and communication networks. They may, in some cases, share devices. For example, an occupancy sensor may be shared between the BAS for HVAC and the lighting control system. In most cases integration shall be limited to monitoring. Each alarm from fire alarm BAS, refrigerant detection BAS, etc. shall be a hardwired digital input to the appropriate stand-alone digital controller (SDC). This level of integration shall be provided only when needed for control of the associated unit(s) during an alarm condition, such as shut down or smoke control operating mode in response to a fire alarm, ventilation mode in response to a refrigerant alarm, etc.

System Architecture Overview: Each DDC Building Automation System (BAS) for HVAC shall communicate with the BAS servers located within the Control Center at the Physical Plant Service Building. Communication shall be through the campus LAN maintained by UIUC Technology Services. DDC at the building level shall be a network of independent stand-alone digital controllers (SDC's). Each SDC shall be capable of full control either as a completely independent unit or as a part of a building-wide control system. Building level SDCs are categorized as building level network (BLN) controllers and floor level network (FLN) controllers. BLN controllers typically control central station equipment such as AHUs, boilers, hot water systems, chilled water systems, etc. FLN controllers typically control application-specific devices (ASDs) such as VAVs, CUHs, FCUs, etc. FLNs are also used to monitor VFDs. Each BLN controller shall be provided with two network interface jacks, one for the controller and another for a portable laptop computer. These shall comply with the UIUC Technology Services coordination procedure submitted in this general overview and within *Section 23 09 23 – Building Automation System (BAS) for HVAC* found within the Technical Sections of these UIUC Facilities Standards. For full details of system architecture see *Section 23 09 23 – Building Automation System (BAS) for HVAC*.

Programming: A single control programming language shall be used for each manufacturer's system and shall be fully programmable from the central host computer, which shall also function as the database server. The system shall utilize client/server architecture, with all points and program databases stored on the server central host computer. All operator workstations shall serve as clients.

Graphics: Each DDC system shall monitor and control equipment as indicated in the Sequence of Operation and points list. A graphical representation of each system shall be made available at all operator work stations. Each system "graphic" shall display all control and monitoring points and alarms. A security hierarchy shall be provided. It shall

limit modifications to the sequence of operation or programming to a select number of personnel at a high security level. User adjustable set points shall be available for change by trained personnel at appropriate security levels.

Licensing: Where required by the system architecture, the vendor shall provide a client license for utilization at the project site. An additional client license along with programming and engineering tools for the installed systems shall be provided to the Facilities and Services Division.

Approved Manufacturers: Currently, new installations of DDC building automation systems for HVAC are limited to the following four approved manufacturers and systems:

1. Siemens "Apogee"
2. Schneider Electric Building Systems " I/A Series "
3. Delta V
4. Andover "Infinity/Continuum" for card access only

Independence: The University retains responsibility for maintaining all control systems on campus including both hardware and software. As such, the University typically does not enter into nor rely upon service contracts with private service providers.

Team Approach: The AE shall work closely with *UIUC F&S Systems and Controls* as well as *F&S Quality Assurance* throughout the design and construction phases of each project. Design decisions shall be made with concurrence of appropriate F&S staff.

Coordination with Information Technologies Engineering: Early in the design phase of a project, the AE shall contact the U of I Information Technologies Engineering at (217) 244-1600 for assistance in locating the CER (Communication Equipment Room) and associated conduit /cable routing. The AE shall show approximate control panel location on the general equipment plan view drawings. Construction Documents shall include the Information Technologies coordination information stated in *Section 23 09 23 –*

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Building Automation System (BAS) for HVAC.

LEED Requirements: Each LEED project shall meet the requirements of the U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) program. Each new project will attempt to achieve the U.S. Green Building Council's LEED Version 2.2 Certification level. The AE shall carefully examine the controls LEED portion and shall attempt to achieve the following LEED points at a minimum:

Energy and Atmosphere:

Prerequisite 1 – “Fundamental Building Systems Commissioning”

Prerequisite 2 – “Minimum Energy Performance”

Credit 3 – “Additional Commissioning”

Credit 5 – “Measurement and Verification”

Indoor Environmental Quality:

Prerequisite 1 – “Minimum IAQ Performance”

Credit 1 – “Outdoor Air Delivery Monitoring”

Credit 2 – “Increased Ventilation”

Credit 6 – “Controllability of Systems”

Credit 6.1 – “Lighting Control”

Credit 6.2 – “Thermal Comfort”

Applications: At a minimum the following equipment and systems shall be fitted with DDC and shall be integrated into the BAS.

1. Central Station Equipment: Includes air handling units and associated return/relief fans, chillers, chilled water pumps, cooling towers, condenser water pumps, chilled water BTU metering stations, boilers, heat exchangers, hot water pumps, hydronic filtering stations, steam condensate return units, sewage ejectors, sump pumps and domestic water booster stations.
2. Exhaust Fans: Includes toilet exhaust, general exhaust, laboratory exhaust and equipment room ventilation fans.
3. Terminal Units: Includes VAV boxes, reheat coils, and perimeter heating units.
4. Room Pressurization Controls (i.e. dynamic monitoring and control of relative room pressurization)
5. Hydronic System DP & SP Control (i.e. control of pump speed and monitoring of system fill pressure)

6. Metering Equipment: Includes meters for domestic water, natural gas, steam condensate and chilled water (as well as steam and compressed air where applicable). Electric metering (kWh), however, shall not utilize a BAS. It shall be designed and installed separately. Modbus TCP protocol shall be used.
7. Utility Service Entrance Devices (e.g. steam, chilled water): Includes temperature and pressure sensors as well as pressure and flow control valves.

Simplicity, Proven Technologies: Also consistent with the Guiding Principles listed above in conjunction with requirements of the section entitled *HVAC Systems*, the following popular quotes shall apply: Einstein: *“Everything should be made as simple as possible, but not simpler.”* Cantrell: *“...so simple it works.”* In keeping with these statements HVAC control systems shall be kept as simple as possible using proven technologies without substantially sacrificing performance opportunities. The following excerpt from the *University of Chicago Standards* shall apply: *“Overly complicated systems may perform exceptionally well on day one, but are prone to deterioration over time. ...An example might be a system that relies on “bleeding edge” technology with which the University’s operations staff has little experience. Note: It is not the intent of the University to stifle innovation...In fact there are many examples of innovative designs that are highly maintainable.”*

Future Expansion: Consistent with the *Guiding Principles* listed above, each HVAC control system shall be configured to accommodate future expansion. For example, a generous number of unused control points and field devices as well as “oversized” auxiliary panels shall be provided to the satisfaction of the Owner.

Accessibility: All BAS components shall be readily accessible to service personnel, inaccessible to the general public and located out of sight.

Control System Naming Convention: The University has developed a standard naming convention for equipment identification and BAS programming. Coordinate with the F&S

Systems and Controls Group early in design development to ensure identification of new and replacement equipment is consistent with this standard naming convention.

Installation: DDC controllers and auxiliary panels shall be installed on free-standing support racks as detailed within the Technical Sections and Drawings within these *Facilities Standards*. Installation of field devices, conduit, wiring and pneumatic tubing shall be as indicated within the Technical Sections within these *Facilities Standards*.

Emergency Power: BAS controllers and field devices shall be powered from external emergency power sources (via emergency panels). Priority shall be given to critical applications including primary hot water heating systems.

Dedicated Circuits: BAS controllers and system components shall be fed from dedicated circuits that do not serve non-BAS equipment or devices.

Non-BAS Control Circuits: Any non-DDC/BAS control circuit associated with a piece of equipment shall be no greater than 120 V. It shall be configured such that it is active only when the equipment it serves is active. Therefore an independent circuit shall not be used to power a non-DDC control circuit.

Safeties: Each safety control device, such as a freeze protection thermostat, a high or low pressure safety switch or a cooling tower vibration switch, shall be hard-wired into the safety circuit (typically of the motor starter or VFD) that serves the associated piece of equipment. In addition, it may also be wired into the BAS for the purpose of generating an alarm. Safety devices shall be installed and wired such that system safeties remain functional even when the BAS is non-functional. All controls shall be configured and programmed for fail-safe operation in response to system upset conditions.

Critical Equipment: Critical equipment/systems shall be continuously monitored and alarmed. Temperature of laboratory cold rooms serves as an example.

Zoning: HVAC systems and associated controls shall be zoned in a manner that facilitates optimized control strategies for reducing energy consumption in conjunction with optimizing human health and comfort. For example, each occupied room shall be treated as a dedicated zone.

Energy Reduction Strategies: Control system layout, devices and programming shall enable full application of energy reduction strategies. Adequate numbers of control and monitoring points shall be provided to accomplish this. Devices such as occupancy sensors and CO2 sensors shall be fully applied.

Control Upgrades: As opportunity affords, pneumatic control systems and obsolete direct digital controls shall be replaced with current DDC as specified herein.

Airflow Monitoring: As stated in the *Ventilation Systems* section within these *General Guidelines*, accurately monitoring airflow presents a special challenge. The University has found standard airflow monitoring stations to be problematic at best. They are often installed improperly resulting in compromised accuracy. They also become dirty quickly yielding a similar result. Thus, proper installation in ductwork with adequate straight run is essential. Annual cleaning and recalibration is required. This is difficult to achieve with limited maintenance staff. Thus, airflow monitoring stations shall be used only as required to satisfy applicable codes and standards. It is acknowledged that they may also be required in accomplishing optimized control strategies when no other viable option exists. Typically, pressure feedback control shall be used in lieu of airflow monitoring stations to provide control of building pressurization. When possible, demand control ventilation using CO2 feedback shall be used in lieu of quantitative airflow monitoring to ensure minimum ventilation air requirements are satisfied. Airflow through monitoring stations shall be filtered if possible.

Pneumatic Controls: Although the control industry continues to move away from the use of pneumatic controls, pneumatic actuators are still viewed by the University to

be superior to electric actuators for high torque applications. Thus, their use is encouraged for such applications.

Compressed Air Source: A dedicated control air compressor unit shall be provided to serve pneumatic controls in each building unless a source of operational campus-wide central compressed air is available. Each air compressor unit shall be a duplex unit sized to maintain adequate control air capacity with neither compressor running more than 33% of the time. Air filters, air dryer and other specialties shall be provided at each compressor unit installation. Installation shall be in compliance with *Drawing TC Control Air Compressor Detail*

Project Documents: Project construction documents shall include the following items often overlooked:

- Schematics for all controlled devices with points indicated diagrammatically directly on drawings.
- Schedules for control valves and dampers including all information required for proper sizing. Schedules shall comply with all requirements presented in *Section 23 09 13.33 – Control Valves*, *Section 23 09 13.34 – Control Valve Actuators* and *Section 23 09 13.43 - Control Dampers*.
- General equipment layout with control panel locations and CER room locations.

Spec Language: AE shall be prudent in the use of the term “capable of” in documents and on drawings. AE shall fully understand that controls providers may not provide the necessary programming when only required to provide “capability”. AE designers shall require the relevant hard-wired and virtual control points and programming code.

