

**5.25.50 - FACILITY CONTROLS – BUILDING AUTOMATION SYSTEM (BAS)  
DESIGN AND CONSTRUCTION STANDARD**

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**PART 1: GENERAL**

1.01 Purpose:

- A. The design guidelines contained herein include the requirements for integrated automation facility controls at The University of Texas at Austin. It is the intention of this document to provide a standard for at the University that represents the highest level of quality and consistency possible.

1.02 References:

- A. ANSI/HFS 100 - Human Factors Engineering of Visual Display Terminal Workstations
- B. IEEE 802 Series - Information and Technology Standards for Local & Metropolitan Area Networks (LAN/MAN).
- C. IEEE Std-1100 - Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.
- D. ISA-5.1 - Instrumentation Symbols and Identification.
- E. ISA-5.3 – Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems
- F. ISA-5.4 – Instrument Loop Diagrams.
- G. NEMA 250 – Enclosures for Electrical Equipment (1000Volts Maximum)
- H. NFPA 70 – National Electric Code.
- I. TIA/EIA-232 - Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
- J. TIA/EIA-485 - Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
- K. Underwriter’s Laboratories – (specify individual standards per project application).

1.03 Requirements:

- A. This section is intended to convey the minimum performance requirements related to integrated automation facility controls of mechanical systems

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operations. Confirm specific controls requirements and goals with Owner early in the design process.

- B. The BAS includes the hardware, firmware and software necessary to obtain the performance requirements by function and system components for operation, reliability, security, packaging, control sequencing, scheduling, loop tuning, interlocks, system integrations, interlocks, commissioning.
- C. The BAS includes equipment such as operator workstations, direct digital control (DDC) panels and controllers, relays, terminal equipment, wiring, cabling, circuit breakers, panel boards, power supplies, and transformers.
- D. Project review milestones are required as follows:
  - 1. Kick-off meeting
  - 2. Submittal reviews
  - 3. Proposed display screen graphics
  - 4. I/O point definitions
  - 5. Alarm Management
  - 6. Control Sequences and Scheduling
  - 7. Pre-Installation meeting
  - 8. Field walk down
  - 9. Final Commissioning
- E. Protect equipment during delivery and storage. Store equipment in environmentally controlled space prior to installation.
- F. Warranty:
  - 1. Period: 12 months after UT acceptance.
  - 2. Integrate new building BAS extended maintenance with existing service agreements.

**PART 2: PRODUCTS**

2.01 Manufacturers:

- A. Acceptable Manufacturers:
  - 1. TAC – Andover Continuum Line, with Infinet protocol.
  - 2. Siemens - Apogee Line, with P1 FLN protocol.
  - 3. These are the only BAS systems acceptable to the University.
- B. Individual buildings shall have either one of the above listed systems; no building is to have a combination of these systems.

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- C. The central monitoring station shall have independent operator workstations for the monitoring and control of each system.
- D. Other existing equipment from Johnson Controls, such as the JC-80 and Metasys control systems shall be phased out using one of the above listed manufacturers.

2.02 Network Architecture:

- A. Communicate via the UT campus-wide VPN (FACNET) WAN operating at a minimum of 100 Mbps for interconnecting on servers, workstations, and building controllers.
- B. Base the first tier network on a PC industry standard of Ethernet TCP/IP.
- C. Network multiple operator workstations, network controllers, system controllers, and application-specific controllers for a complete BAS. The first tier network shall provide communications between operator workstations and first tier DDC (Direct Digital Control) controllers.
- D. Existing systems use a primary application server and a backup server which interface to the system processes. The primary server is located remotely from the backup server. The system data is mirrored on the servers and automatically switches from primary to the backup upon loss a server. When system is expanded, due to new building additions, determine the adequacy of the server size and increase server capabilities as necessary to ensure operations reliability and speeds.
- E. The existing system also provides system information to outside users via a web server; coordinate with UT IT Department for firewall and security requirements. Modems, wireless devices or other remote type communication devices which circumvent network security shall not be used for access to the BAS.
- F. Building communications connections shall be by UT. Coordinate location, and cabling details with UT.
- G. Second tier networks shall provide either "Peer-to-Peer," Master- Slave, or Supervised Token Passing communications, operating at the fastest available communication speed, with a minimum of 9600 baud.
- H. The BAS shall include appropriate hardware equipment and software to allow two-way data communications between the BAS and 3<sup>rd</sup> party manufacturers' control panels. A minimum of 100 third-party controllers shall be supported on a single network.

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- I. Provide repeaters to detect and repeat signals from one LAN segment to other segments.
  - J. Provide gateways for integrating third party systems using Modbus, Devicenet, or DH+ protocols. OPC servers can also be used for diverse system integration. The OPC Server shall have the following characteristics and functionality:
    - 1. Run on Microsoft OS Based machines connected via Ethernet to the BAS.
    - 2. Allow generic components to be used and shared with other OPC-compliant clients and systems.
    - 3. Serve as the "translation service" for the various languages used by the diverse systems with which it communicates.
    - 4. Support multiple OPC clients running on both local and remote machines in the network.
    - 5. Control the interaction and communication between workstation applications (on clients) and the BAS by providing standard methods for sharing and exchanging data between the BAS and other systems.
    - 6. Provide interfaces for browsing, reading, and writing accessibility.
  - K. Isolation shall be provided at all network terminations, as well as all field point terminations, to suppress induced voltage transients.
- 2.03 System Software:
- A. Provide integrated multi-tasking software package for operator interface use to control and monitor the BAS. The same programming language will be used for controllers, networks, algorithms, alarms, I/O points, calculations, and control sequences.
  - B. Provide workstation graphics similar to those already used for like in kind system applications at UT Austin main campus.
  - C. Software programs shall be fully described with annotations in each section such that others may follow and understand the original programmer's logic and intent of the software code.
  - D. Provide system application software functions:
    - 1. Graphics:
      - a. Add, delete, or change graphics on line.
      - b. Library of standard HVAC equipment such as boilers, chillers, air handlers, terminals, fans, pumps, instruments, valves.
      - c. Dynamic (animated) and static displays.

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- d. Display alphanumeric text and data.
- e. Equipment operating status.
- f. Alarms.
- 2. Display screens for:
  - a. Campus map: campus and remote sites divided into geographic sections.
  - b. Building grid: tabular form using 3 letter acronyms for each building, arranged alphabetically on the grid.
  - c. Diagnostics: main system diagnostics with links to the buildings.
  - d. Building floors: general status information (room temperature & humidity) on overall graphic and enlarged floor plans.
  - e. Occupancy schedule.
  - f. Alarm summary and history: active and acknowledged alarms in tabular format last in at top of list; alarms stored in history after acknowledged and alarm condition cleared.
  - g. Equipment performance: based on systems.
  - h. Trending and reports: graphical and tabular format of system operations.
  - i. Control tuning: links to system equipment for loop tuning.
  - j. O&M Information: links to BAS equipment operations and maintenance manuals, including as-built drawing information.
- 3. System configuration.
- 4. Controller PID tuning.
  - a. Group all interrelated process points on same graphic screen.
  - b. Log tuning data.
  - c. Document loop tuning results from bump tests.
- 5. System database.
- 6. System historian. Provide historical logs in logical groups for system operations:
  - a. Collect data at 15 minute intervals
  - b. Average data over 72 hour window
  - c. Archive historical data to DVD when server memory capacity is at 50%
- 7. System clock synchronization.
- 8. System diagnostics.
- 9. Security:
  - a. Password access. Minimum of 5 levels of access related to system operational control, monitoring, and programming functions.
  - b. Virus protection. Spam and Adware S/W.
- 10. Alarm Management:
  - a. Classification:

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- 1) Critical: conditions that require immediate action by the operator for personnel safety, equipment protection, and major equipment alarms.
  - 2) Non-critical: those that will not disrupt system operations.
  - 3) Application specific: those that are related to research versus office environmental controls.
    - a. Configurable: Normal or bypassed.
    - b. Setpoint: adjustable limits.
    - c. Equipment status.
    - d. I/O point range validation.
    - e. Event log date, time, and operator actions.
    - f. Alarm response audit trail.
    - g. Email notification.
11. Reports:
- a. Energy usage.
  - b. Equipment runtimes.
  - c. Equipment status.
  - d. Alarm summary.
12. Trend logs:
- a. Real time and historical data.
  - b. Up to 8 parameters on same trend.
  - c. Adjustable time and magnitude scales.
  - d. Triggered trends based on preset parameter changes:
    - 1) Chilled water delta temperature drop
    - 2) Chilled water delta temperature rise
13. Schedules:
- a. Start/stops.
  - b. Time of day.
  - c. Temperature optimization.
  - d. Demand Limiting.
  - e. Day/night setback.
  - f. Weekly, monthly, holiday by system.
  - g. Temporary overrides.

2.04 System Performance:

- A. Provide controllers that execute PID control loops at a frequency not to exceed 1 second. The process variable scan and updated calculated output rate is at same rate.
- B. Custom and standard application execution times must be consistent with or faster than mechanical processes under control.
- C. Graphics update rates:

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1. Display Refresh: 20 dynamic points in 5 seconds
2. Object Command: 2 seconds
3. Object Scan: 2 seconds
4. Alarm Response Time: 5 seconds when point goes into alarm
5. Multiple alarms: 3 seconds of each other

- D. Control Loop Stability:
1. Air Pressure – 0.2” WG
  2. Airflow – 100cfm
  3. Temperature – 1F
  4. Humidity – 5% RH
  5. Fluid Pressure – 1.5 psi
  6. Fluid Flow – 2%

2.05 System Diagnostics/Failure mode:

- A. Provide the BAS with system diagnostic programs to include:
1. Initiation Checks
  2. On-Line Diagnostics
  3. Off-Line Diagnostics
- B. Provide diagnostic programs with alarms to alert the operator upon detection of a fault.
- C. Provide BAS software to re-initialize system upon fault or power restoration, unless operator intervention is deemed necessary.
- D. Provide BAS software so that the system will fail in a predictable manner to ensure integrity and safety of system equipment and operation.

2.06 Operator Interface:

- A. Utilize existing operator workstations in the central control room or directed otherwise by UT.
- B. Operator workstation based on Dell commercial off-the-shelf personal computer (PC) hardware, AE to specify equipment (hardware and/or software) as needed; workstation components include:
1. Dual flat panel monitors.
  2. Laser color printer
  3. Dual network interface card
  4. Sound card
  5. Mouse
  6. Keyboard

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- C. If specified in the Project Documentation, provide a portable operator terminal for command entry, information management, network alarm management, database management, system diagnostics, interrogate and re-program any point in the system from any DDC panel.

2.07 Web Browser:

- A. Web browser access is through the UT Austin campus LAN, which is protected by a firewall.
- B. Provide a Thin Client web browser function, with intuitive mouse/menu driven interface, to view process data via local or wide area networks.
- C. Provide objects such as:
  - 1. Point record value
  - 2. Point summary information
  - 3. Trending Logs
  - 4. Process Diagrams
  - 5. Schedules
  - 6. Reports
- D. Provide security and access control through a login page that requires a user login and password.
- E. System data monitoring and control function access dependent upon assigned role privileges and area of responsibility.

2.08 Controllers:

- A. Configure to maximize the standalone operation of the BAS system for each logical group of equipment if communications are interrupted. Real-time control functions, including scheduling, history collection and alarming, shall be resident in the BAS controllers to facilitate greater fault tolerance and reliability.
- B. Network Controller: interfaces applications specific controllers together, to other network segments, and to the system servers/ operator workstations.
  - 1. Provide microprocessor based controller:
    - a. Word size of 16 bits
    - b. Scan rate 1 second (maximum)
    - c. Memory as needed for its self function and lower tier controllers.
    - d. Real time clock.
    - e. Communications:
      - i. Open system port.

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- ii. Two EIA-232
  - f. Initial configured such that only 80% of the available nodes are used for system installation.
  - g. Each Network Controller shall store trend and point history data for all analog and digital inputs and outputs.
  - h. Network Controllers shall be fully user-programmable supervisory controller. The Network Controller shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Controllers. Controllers shall be listed by Underwriters Laboratories (UL).
  - i. Internal or external transient voltage and surge suppression shall be provided for workstations and controllers.
- C. Application Specific Controllers: configured to maximize the standalone operation of the BAS system for each logical group of equipment.
  - 1. Operates as standalone controller for equipment such as:
    - a. Boiler
    - b. Chiller
    - c. Cooling Towers
  - 2. I/O points (Refer to standard I/O points list)
  - 3. Local display
    - a. Point data
    - b. Audible and visual alarm indication
    - c. Password protected
  - 4. Memory sufficient for control programs and historical logging buffer for equipment group.
  - 5. Local override with auto-off-on switches.

2.09 Control Panels:

- A. Provide NEMA rated hinged indoor control cabinets/panels, according to location service hazards.
- B. Provide panels as wall or floor mounted (on legs or house keeping pad).
- C. Provide UT standard CH751 lock cylinder on each panel.
- D. Panels for electronic control equipment shall be vendor's standard color with standard UT panel labels

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2.10 Power Supplies:

- A. The BAS shall be powered from an electrical distribution panel that is backed by the facility's UPS.
- B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure. Unit shall operate between 32°F and 120°F. EMI/RFI shall meet FCC Class B. Line voltage units shall be UL recognized and CSA listed.
  - i. Internal or external transient voltage and surge suppression shall be provided for workstations and controllers. Surge protection to include:
    - 1. Dielectric strength of 1000 V minimum
    - 2. Response time of 10 nanoseconds or less
    - 3. Transverse mode noise attenuation of 65 dB or greater
    - 4. Common mode noise attenuation of 150 dB or greater at 40- 100

**PART 3: EXECUTION**

3.01 Factory Acceptance Test (FAT)

- A. The FAT test procedure shall provide step-by-step instructions and data sheets for test personnel to follow and complete while testing the system.
- B. The FAT shall test the system hardware and software including:
  - 1. Input/Outputs.
  - 2. Display Screens
  - 3. Field Controllers and control loop tuning.
  - 4. I/O Database Verification.
  - 5. Network Connections and I/O Wiring Terminations.
  - 6. Data throughput.
  - 7. System sequence of operations.
  - 8. System response times.
  - 9. System Failure modes/Self Diagnostics.
  - 10. System interfaces with third party equipment.
  - 11. System Security.
  - 12. System Web Access.
  - 13. Data trending (real time and historical) and reports.

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3.02 Site Acceptance Test (SAT)

- A. The site acceptance test shall be field initiated and observed, not simulated.
- B. The SAT/Commissioning shall test 100% of all field devices through the BAS I/O points and as displayed on the graphic displays.
- C. All test design and commissioning shall be designed and performed using the deliverable “AS BUILT” control drawings, graphics and control programs.
- D. Control sequence and operation shall be verified by system reaction to signal from device(s).
- E. The SAT procedure shall be based on the FAT test procedure with the exception that the inputs and outputs shall be field initiated and observed, not simulated.
- F. The SAT shall test the system hardware and software including:
  - 1. Input/Outputs.
  - 2. Display Screens
  - 3. Field Controllers and control loop tuning.
  - 4. I/O Database Verification.
  - 5. Network Connections and I/O Wiring Terminations.
  - 6. Data throughput.
  - 7. System sequence of operations.
  - 8. System response times.
  - 9. System Failure modes/Self Diagnostics.
  - 10. System interfaces with third party equipment.
  - 11. System interface with the existing WDPF II system.
  - 12. System Security.
  - 13. System Web Access.
  - 14. Data trending (real time and historical) and reports.
  - 15. Asset management functions.
  - 16. Simulate addition of field devices, logic program changes, generation of custom graphics and reports.
  - 17. Verification of “AS BUILT” drawings.
- G. Final performance testing shall confirm the following:
  - 1. Maximum overshoot of 20%.
  - 2. Achieve stability in 5 minutes or less depending on system control sequences.
  - 3. Initial response of 20% command within 1 minute.
  - 4. Anti-hunting/minimum cycling of control loop.
- H. A test report shall be submitted upon completion of testing activities

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3.03 Training:

- A. Training shall be specific to each Project. The Project Documentation will detail the training required which may include any, all or additional areas of training to those listed below.
  
- B. Controls system training shall be provided to UT Austin staff by controls contractor and controls system manufacturer. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods as determined by UT Austin per project. Instructors shall be factory-trained and experienced in presenting this material. Classroom training shall be accomplished using a network of working controllers representative of installed hardware.
  
- C. Training shall enable students to accomplish the following objectives:
  - 1. Proficiently operate the system
  - 2. Understand control system architecture and configuration
  - 3. Understand DDC system components
  - 4. Understand system operation, including DDC system control and optimizing routines (algorithms)
  - 5. Operate workstation and peripherals
  - 6. Log on and off system
  - 7. Access graphics, point reports, and logs
  - 8. Adjust and change system set points, time schedules, and holiday schedules
  - 9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
  - 10. Understand system drawings and Operation and Maintenance manual
  - 11. Understand job layout and location of control components
  - 12. Access data from DDC controllers
  - 13. Operate portable operator's terminals
  - 14. Create and change system graphics
  - 15. Create, delete, and modify alarms, including configuring alarm reactions
  - 16. Create, delete, and modify point trend logs (graphs) and multipoint trend graphs
  - 17. Configure and run reports
  - 18. Add, remove, and modify system's physical points
  - 19. Create, modify, and delete application programming
  - 20. Add operator interface stations
  - 21. Add a new controller to system
  - 22. Download firmware and advanced applications programming to a controller
  - 23. Configure and calibrate I/O points

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24. Maintain software and prepare backups
25. Interface with job-specific, third-party operator software
26. Add new users and understand password security procedures

D. Presentations of objectives shall be divided into three sessions (1-13, 14-23, and 24-26). Participants will attend one or more of sessions, depending on knowledge level required.

1. Day-to-day Operators (objectives 1-13)
2. Advanced Operators (objectives 1-13 and 14-23)
3. System Managers and Administrators (objectives 1-13 and 24- 26)
4. System Administrator (objectives 1-26).

3.04 Sequence of Operation:

- A. Equipment sequence of operations shall be shown within the mechanical drawings or specifications for each system/component, including, air-handling unit, fan, pump, chiller, boiler, air compressor, heat exchanger, terminal heating and cooling unit and any other BAS monitored or controlled device.
- B. Two sets of “AS BUILT” documentation shall be delivered to UT.
- C. Two sets of “AS BUILT” control programs and points list shall be delivered to UT.

3.05 Typical Points List:

- A. Provide points lists for each major piece of mechanical equipment and balance of plant equipment in the construction documents.
- B. See Appendix for typical equipment points list.

END OF STANDARD