SECTION 23 09 00 - INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. These standards are minimum university requirements only. They are designed to clarify the university needs. They are not intended as a substitute for design services. Consultant shall provide a complete design and specification for the Building Automation Systems (BAS). This section may be referenced or portions copied and inserted into the specifications to clarify the university requirements. However, the design and specifications are the responsibility of the consultant not the university.

B. The Building Automation System (BAS) shall be a complete and fully integrated, microprocessor based BAS for control of HVAC and Building Environmental Processes.

C. The BAS shall interface with the lighting control system to schedule the HVAC system occupancies.

D. The Building Automation System applies only to the University of Colorado Anschutz Medical Campus. Contact the University Project Manager for Building Automation information regarding the University of Colorado Denver applications.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. The engineer shall clearly specify responsibilities between the BAS contractor, the TAB contractor the terminal box manufacturer and all other sections to provide a complete system that is installed without overlap.

1.3 SUBMITTALS

A. General:
   1. All submittal items in this section are in addition to Division 1.
   2. Submittals shall be complete, with detailed information on all items provided.
   3. All submittal requirements specified shall be provide as a single bound package. Provide six (6) submittal copies or the amount specified in Division 1, whichever is greater.

B. Submit AutoCAD (or AutoCAD compatible through DXF conversion) generated schematic in hardcopy and electronic media for the entire control system, for review and approval before work shall begin. The hardcopy drawings shall be submitted on 8-1/2” x 11” or 11” x 17” sheet with drawings information sized such that all drawing information is legible. The submittal drawings shall include the following:
   1. Communications:
      a. Provide a one-line diagram depicting the system architecture complete with a communication riser and peripheral devices.
      b. Provide a tabular listing of locations of controlled equipment, communications and network wiring layout, and panel locations with unit communication address identifiers.
   2. Point-to-point wiring diagrams for each HVAC system accurately depicting:
      a. Complete termination and configuration of all wiring and pneumatics. (This includes termination points for wires that are terminated on equipment supplied by others.)
      b. all temperature controls located on a schematic diagram of the controlled HVAC system
      c. start-stop wiring for each piece of equipment
      d. equipment interlocks
      e. wiring terminal numbers
      f. any special connection information required for properly controlling the mechanical equipment.
   3. Panel interior and panel face layouts.

C. A bill of material reference list with drawing tag identifiers, application description, manufacturer, complete model number, and quantity.

D. Identify all deviations from this standard and project documents.

E. Provide written sequences of operation which shall define all modes control strategies.

F. The submittals shall include manufacturers catalog data describing each item of control equipment or component provided and installed for the project.

1.4 WARRANTY

A. The BAS shall be warranted to be free from defects in both material and workmanship for a period of one (1) year of normal use and service. This warranty shall become effective the date the university accepts the system. The warranty shall include 24 hour per day, 7 day per week emergency problem response and all standard service contract preventative maintenance items (i.e. sensor calibration, linkage adjustment, etc.). An emergency service number shall be provided to the university. Response shall be within four (4) hours to the phone call.

B. Provide factory trained technicians familiar with the installation for emergency warranty service.

C. Upgrades: Include all controller firmware and software updates for the installed system version at no additional cost to the system the university during the warranty period.

D. Tuning: Include seasonal fine-tuning of PID loop parameters and other control parameters to provide an optimized control system to the university.

1.5 QUALITY ASSURANCE

A. Installation:
1. The control system shall be furnished, engineered, and installed by the BAS manufacturer's local office.
2. Certain wiring and pneumatic installation may be performed by the BAS installer/manufacturer's approved subcontractor under the direct supervision of the BAS installer/manufacturer's field management.

B. Control system components shall be new and in conformance with the following applicable standards for products specified.
1. American Society for testing and materials, ASTM
2. Institute of Electrical and Electronic Engineers, IEEE
3. National Electrical Manufacturers Association, NEMA
4. Underwriters Laboratory, UL 916
5. Underwriters Laboratory, UL 855 (Smoke Control Only)
6. FCC Regulation, Part 15, Section 156
7. National Fire Protection Association, NFPA
8. Applicable Building Codes

1.6 SYSTEM DESIGN REQUIREMENTS

A. Campus Building Automation System Design Intent.
1. Provide a single vendor, stand-alone Building Automation System (BAS) within each new or retrofitted building. Integrate the stand alone systems via the campus BAS data network.
2. Systems shall be designed to be BACnet compatible.
3. System shall be designed as an effective easy to use tool to operate, control, monitor and alarm mechanical equipment.

4. The system shall include all DDC controllers, sensors, valves, actuators, dampers, transmission equipment, software, local workstations, local panels, installation, setup, engineering, supervision, acceptance testing, training, and warranty necessary for a complete operable system.
5. The BAS shall be a full control system designed to control terminal equipment as well as main systems.
6. Each building and or renovation project shall provide adequate devices for monitoring and operating the BAS.
7. Each building shall include one or more BAS workstations to, based on password, allow full access to system configuration and monitoring.

B. System Architecture:
1. The BAS control system architecture shall be comprised of four levels of DDC controls devices.
   a. Level 1: The first level is the system instrumentation component devices that includes but is not limited to sensors, valves, actuators, switches, relays, and transducers.
   b. Level 2: The second level includes the terminal equipment DDC controllers with specific applications for control of terminal units such as VAV boxes, fan coils and unit heaters.
   c. Level 3: The third level is comprised of general application DDC controllers for control of large primary mechanical systems such as air handling systems, heating hot water systems and chilled water systems. This level also performs system networking functions.
   d. Level 4: The fourth level consists of a file server, workstations and other devices that provide access, programming and setup tools, database management and other functions.
   e. Provisions for expansion of all levels of the DDC system shall be provided with each project such that a need for future “gateway” or “repeater” expansion hardware and software is not required.
2. Alternates:
   a. Variations from this general outline should meet the following functionality and be approved by the university.
   b. Non-intelligent slave panels may be utilized only to expand the controller point capacity for control of a single HVAC system, or specified monitoring not requiring control logic.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved BAS Installers/Manufacturers:
1. University of Colorado Anschutz Medical Campus: Siemens Building Technologies
2. University of Colorado Denver: Contact the University Project Manager

2.2 SYSTEM AND CONTROLLERS

A. All systems shall be configured and designed to be stand-alone.

B. All outputs including all outputs attached to terminal equipment controllers and special applications shall be directly commandable by the system operator. Any application that has outputs that can not be commanded by the operator shall not be accepted.

2.3 Terminal Equipment Controllers

A. Terminal Equipment Controller Hardware
1. General:
   a. Each terminal equipment controller shall be a stand-alone DDC controller designed specifically for terminal unit control such as VAV boxes, fan coil units, heat pump units or similar application.
   b. The controller shall execute local control sequences, independent of a network controller or workstation.

c. All controllers shall preserve setup and programming from a loss of power for a minimum of 7 days.

2. Programs:
   a. The control program shall reside in the terminal equipment controller.
   b. The default data base, i.e. setpoints and configuration information, shall be stored in EEPROM or other non-volatile memory.
3. Stand-Alone:
   a. Controllers that share processing with a "master controller" shall not be acceptable.
   b. After a power failure the terminal equipment controller must run the control application without having to contact another controller..
4. Communications:
   a. Communications to the general application controller shall maintain the specified network throughput speed specified in the network controller hardware section.
5. Isolation:
   a. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watts at 3 feet.
6. Connections:
   a. All electrical connections shall be made to a combination terminal strip and base assembly.
   b. To insure long term reliability, all electrical terminations shall be screw type.

B. Terminal Equipment Controller Software:
1. Controllers shall be provided with the capabilities required by the application.
2. Each input, output or calculation result shall accessible from the terminal equipment controller communication port, application controllers and workstations.
3. Controllers that require an EPROM burn to make permanent changes to the software configuration shall not be acceptable.
4. All outputs for all controlled devices shall be directly commandable from the general application or network controller and from any workstation.
5. Global commanding of outputs and setpoints shall be available to command any number of similar terminal equipment controller outputs to the same position with a single command.
6. Terminal device controllers that do not allow separate space heating and space cooling setpoints to be configured shall not be accepted. This includes setpoint dial applications.

2.4 GENERAL APPLICATION CONTROLLERS

A. Hardware
1. General
   a. The controller shall support all of the standards for the front-end software such as trending, alarming, etc.
   b. The general application controllers shall be a local control loop microprocessor-based controllers installed at each mechanical system; (i.e., air handling units, heating plants, chiller plants, etc.).
   c. The controller provides uplink and downlink communications, polling and other supervisory functions for terminal equipment controllers.
   d. Mechanical systems in close proximity with a small number of physical inputs and outputs may be combined in controllers with modular input output layouts.
   e. The controller shall be a true no-host system that does not require a PC or "Host" computer to perform any control functions or communication.
   f. Each controller shall be addressable by a workstation or a portable service tool.
   g. Non-intelligent slave panels may be utilize only to expand the controller point capacity for control of a single HVAC system, or monitoring without control logic.
   h. Self Diagnostics: The controller shall contain in its program, a self-test procedure for checking communications and, verify the functionality of the CPU memory.
   i. All equipment located on the roof shall be provided with an extra data drop for laptop connection. Locate roof mounted equipment in conditioned enclosures.

2. Each controller shall be provided with the memory capacity to store 1000 data samples for each physical analog point and 100 data samples for each physical digital point.attached to it (including all expansion boards) and 400 data samples for each terminal equipment controller attached. This shall be in addition to the memory needed for all other functions of the panel.
3. Power Loss/Restart: The controller shall be tolerant of power failures. The memory shall be nonvolatile or unit shall hold memory for a minimum of four hours.
    a. Automatically and without operator intervention, the controller shall execute these restart procedures:
        1) Come on line
        2) Update all monitored functions
        3) Implement special building start-ups strategies as required
        4) Resume operation based on current time and status
    b. Controllers with batteries shall provide an alarmable point to the front end workstations when the batteries need to be replaced.
4. Network:
    a. Each general application controller shall connect to the campus Ethernet system.
    b. Multiple system workstation operators shall be able to access the controller simultaneously. Systems which do not provide multi-tasking, multi-user operating systems shall not be acceptable.
    c. Communication speed of each network shall have a maximum 10 second end-to-end throughput from a Level 1 device input to a Level 1 device output, anywhere in the system. Provide a system configuration that will maintain this minimum throughput speed during trend collection, recovery from power outages, and monitoring of multiple mechanical systems. Strategies to limit traffic shall not interfere with control or system monitoring.
    d. Uploading trends shall not interfere with control or monitoring operations
5. Isolation
    a. Control, communication and power circuits for each controller shall be individually electrically isolated to protect against transients, spikes, and power surges.
    b. The ports shall be optically and/or electrically isolated from each other, the controller circuit board and from power wiring.
    c. The controller shall be able to operate at 90% to 110% of nominal voltage rating.
    d. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watts at 3 feet.
6. Servicing:
    a. For ease of servicing, each controller shall consist of a removable plug-in circuit board.
    b. Products which require disconnection of wiring from the general application controller logic card before removal shall supply and install a quick disconnect type interconnection.
    c. If an air handler is located on the roof, locate equipment in conditioned enclosure of air handler.
7. Input/Output Modules:
    a. Analog inputs shall accept industry standard analog signals such as 4-20 mA, 0-5 VDC, and 0-10 VDC.
    b. Digital inputs shall accept binary contact closures.
    c. Digital outputs may be form C, latched or momentary contact type as required by the application.
        1) Digital output pairs controlling a tri-state motor/transducer or pulse width modulation shall not be utilized by general application controllers.
        2) Provide all digital outputs with hand/off/auto switches and LED status indication.
    d. Analog outputs shall have a 1% resolution over total output span of 0 to 100%.
        1) Provide all analog outputs with manual override switches and pot adjustments.
    e. Provide each control panel with a minimum 10% spare of each input and output type.

B. General Application Controller Software:
1. Provide complete controller software to execute all mechanical system local loop controls functions.

2. Controllers that require an EPROM burn to make permanent changes to the software configuration shall not be acceptable.
3. Each input, output, or calculation result shall be capable of being assigned to the network controller for system networking.
4. Each controller shall be fully programmable both from a portable service tool at the controller and through the network communication system from the front-end workstation. Programs shall be able to be changed online without effecting other programs or point monitoring.

2.5 FRONT-END SOFTWARE

A. BAS Seat License
1. Licenses shall be by concurrent user. Software shall be able to be installed on as many computers as necessary without additional licenses.
2. Each building shall provide a minimum of one seat license.
3. Additional licenses required are one seat license per 200,000 sq. ft. of lab or animal space and one seat license for every 400,000 sq. ft. of office and education space. No individual building shall be required to provide more than two seat licenses.

B. Software shall be a complete package including report management, alarm management, sequence programming language, live and historical data plotting capability, complete graphics with a library of HVAC symbols, program files for mechanical equipment and animation capabilities.

C. Software shall allow operator configurable reports that list in columns points chosen by the operator and attributes chosen by the operator.

D. Amount of trend data stored on the file server shall be limited only by the file server disk size and the discretion of the system administrator. Uploading data shall not effect the operation of the system.

E. Trend data shall be stored in an ASCI file for retrieval by standard “off-the-shelf” software programs.

2.6 WORKSTATION

A. Provide a minimum of one desktop workstation per building.
1. Newest version of Windows approved by the university ITS department
2. Processor speed, memory, should meet specifications necessary to run front-end BAS software without delays
3. Minimum RAM: one Gigibyte
4. CD reader/writer: DVD ROM/CD-RW
5. Ports: USB
6. Monitor: Minimum 17” flat panel LCD
7. Network: Provide an ethernet PC Card compatible with the campus BAS network.
8. Printer: Color Inkjet

B. The server-client workstations shall communicate via a campus-wide ethernet.

C. Perform all administrative tasks including but not limited to control program editing, graphics setup, alarm management, trend management, point setup, point commanding, report management and system setup.
1.

2.7 PORTABLE OPERATION WORKSTATION HARDWARE:

A. Provide one (1) portable operator workstation which shall run the workstation software and includes the following minimum hardware configuration:
1. Newest version of windows approved by the university ITS department

2. Processor speed, memory, should meet specifications necessary to run front-end BAS software without delays
3. CD reader/writer
4. Ports: Serial and USB
5. Monitor: Minimum 13" active matrix color LCD, Resolution sufficient to run BAS graphics without scrolling.
6. Power: Battery Life – 6 hours minimum. Provide Lithium-Ion type. Include (2) AC adaptors and (2) batteries.
7. Network: Provide an ethernet PC Card compatible with the campus BAS network.
8. Weight: 7.0 lbs. Maximum

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Provide a project manager who shall, as part of his duties, be responsible for the following
   1. Coordination between the Contractor and all other trades, the university, local authorities, and the design team.
   2. Scheduling of manpower, material delivery, equipment installation and checkout.
   3. Maintenance of construction records such as project scheduling and manpower planning and AutoCAD for project co-ordination and project record drawings.

B. Mount all panels at eye level in a workmanlike manor.

3.2 SYSTEM SETUP

A. Nomenclature: All point names shall comply with the existing point naming conventions. See Section 23 05 53 and the standard points list.

B. Point Setup
   1. See Section 23 09 32 for a list of required points.
   2. All physical analog outputs shall be setup to be commandable from the graphics with units of percent open to the energy source. This means mixed air dampers will be in percent open to outside air. The value of the physical units of the output shall also be available as live data.
   3. Points shall be setup so they read on reports and graphics with standard engineering units and without decimal places that exceed point updating or sensor accuracy.
   4. A graphic link will be installed for all points that are alarmed to allow drag and drop of alarms from the alarm status application to the appropriate graphic panel.

C. Trends
   1. All general application controller physical points, setpoints, and points on graphics shall be trended.
   2. All trends shall be scheduled for data transfer from the field panels to the database without data loss and without interfering with system operation.
   3. For archiving purposes, trends shall be setup to automatically transfer from the system database to files that can be easily used by standard spreadsheets.
   4. Analog points should have an interval trend of 15 minutes, 200 samples at the panel, and 45 days in the database.
      a. A change of value style of trend will be setup to record significant changes between the fifteen minute intervals.
   5. Digital points shall have change of value trends with a minimum of 50 changes from on to off or off to on stored in the panel, and 500 at the database or as needed for 45 days of data. Additionally, interval trend of 15 minutes, 200 samples at the panel, and 45 days at the database.

D. Locations

1. The room number for the mechanical system needs to be on the graphic. Where points on the graphic are not in the same room as the system, the location shall be in the point setup that can not be accidently deleted during manual manipulation of the point or on the graphic.

E. Graphics
1. The graphics should include all devices used by the control system and all controlled equipment.
2. The university must approve all graphic panels before they are copied.
3. All physical IO shall be on a graphic that enlightens the user to its function. All systems shall have graphics that convey accurate and complete schematic information about the equipment.
4. Graphics shall be clear and readable. Misleading details like construction room numbers and fonts that are too small to read shall not be used.
5. Use typical graphic developed by the university when available otherwise match existing style.
6. Each building will have a Building Chart that lists major AHU and building system parameters. It should be linked to each system graphic and the main graphic.
7. AHU graphics must contain utility and general information on the graphic. An air handler graphic shall have outside air and the properties of any chilled water, heating water, or steam supplied to the air handler.
8. The graphics shall either have links to all relevant graphics or be setup such that the operator will be able to navigate from the terminal box graphic to the relevant air handler graphic and back in less than three double clicks. The same shall be true between the terminal graphic and the related floor plan.
9. Each system graphic shall have a link to the sequence and a link to a maintenance log file.
10. Equipment references on the graphics will be compatible with the campus database naming conventions.
11. Controllers and miscellaneous alarm points will be located on the floor plan graphic.
12. Terminal equipment controller graphics shall be schematically correct, clear to read and have points arranged in a logical pattern to help viewer find information.
    a. All terminal box controllers, fan coils, unit heaters, exhaust boxes, etc. shall be located on a floor plan with a link to the relevant graphic.
    b. Terminal device graphics must contain utility and general information on the graphic. This would include supply air temperature, static pressure, heating water supply temperature or chilled water supply temperature as applicable.
    c. Terminal device graphics shall distinguish graphically between the type of equipment controlled such as VAV boxes, fan coils, hoods, general exhaust boxes ect..
    d. Points on the graphics that indicate position of terminal equipment controller outputs will read in percent open to energy source. All points necessary to command the outputs will be included on the graphics.
    e. Graphics shall be application specific with information on the discharge air temperature and pressure information specific to the air handler serving the terminal equipment controller.
13. Room numbers shall be included on the floor plans and shall be the university room numbers not the construction room numbers.
14. The operator shall be able to print any graphic including the live data.
15. Locate BAS panels on floor graphics.
16. Provide a graphic that overlays the mechanical contract drawing over the floor level graphics. Coordinate with BAS through the University Project Manager.
17. Show the miscellaneous points on the floor overview graphic at the installed location.
18. All points shall drag and drop and open the graphic associated with the point.
19. The graphics file shall be named the same as the background Designer file.

F. Alarms
1. Point alarms should follow the Standard Points List.
2. All general application controller and network controller communication failures shall be annunciated at the applicable system workstations as an alarm.
3. Priority 3 alarms shall be setup for failed batteries at the field panels.

4. All specified I/O device alarms shall be annunciated at the system workstation with alarm messages that clearly identify the type of alarm, the point in alarm and the value of the point in alarm.
5. All alarms shall be assigned priority levels with different notification strategies attached to each level. These alarm levels shall conform to the standards points list (see Section **23 09 32**). The system administrator shall have complete control over notification strategies and alarm levels.
6. Alarm priorities
    a. Priority 1: Life safety (oxygen alarms, fire alarm), alarm effects entire building operation or research, emergency showers, water detection, environmental chambers, and emergency chilled water system activation.
    b. Priority 2: Research area/building alarms
    c. Priority 3: Office and teaching/building area alarms
    d. Priority 4: General maintenance alarms, such filters that do not require an immediate response
    e. Priority 5: BAS alarms, error codes, field panel failure alarms, battery alarms, non building related alarms
    f. Priority 6: Customer equipment alarms
7. All alarms with high priority shall be annunciated on alphanumeric pagers.
    a. Pager messages shall be fully changeable by the system administrator. They shall clearly identify the type of alarm, the building, the point in alarm and the value of the point in alarm.
    b. Critical alarms shall be sent to the paging system within 10 seconds .
    c. All paging shall be enhanced to include a minimum time delay, unless it is a critical alarm.
8. The alarm logic shall include adjustable high and low alarm limits, mixed mode expressions, and equipment interlocks.
9. Unique high and low limits shall be supplied for each analog alarm point in the system.
10. The system shall be programmed to suppress alarm reporting on primary equipment that is in the inactive state.
11. All alarmed points where the location is not obvious must have the location of the point in the point informational text or graphics.
12. Nuisance alarm suppression
    a. Alarms shall have an adjustment delay for the alarm condition to clear before the alarm is sent to workstations or pagers. If the condition clears before the delay is over the alarm shall not be sent.
    b. When the alarm conditions clears there shall be an adjustable time delay before an alarm clear is sent. If the alarm condition clears before the delay is over then no alarm clear shall be sent and the point shall remain in alarm.
    c. Provide enhanced alarming for filters, temperatures, and pressures using enhanced alarming.
13. All alarmed points where the location is not obvious must have the location of the point in the point informational text or graphics.
14. Confirm paging of alarms with the university BAS staff.

G. Database:
1. After all punch list items have been completed export all of the following items and turnover to UCD:
    a. All points for every panel, including Virtual Points
    b. All terminal device points
    c. All programs
    d. All panel database files

H. Reporting:
1. Create the following reports:
    a. Trend Collection report
    b. Operator report
    c. Failed Point Report.

2. For archiving purposes, fifteen minute interval reports should be setup for each mechanical system. Once a month they should automatically export last month's data to a csv file on the file server. File names will be organized logically and include the date and system.

I. Graphing
1. Create the following graphs:
a. Historical graph for the last 45 days of performance for each major mechanical system.
b. Dynamic graph of performance for each major mechanical system.

3.3 COMMISSIONING

A. Engineer shall include a complete specification for testing all BAS components as part of Section 23 08 00. Final testing shall not begin until after system is connected to the campus system and accessible from existing workstations.

B. Project Record Documentation:
1. At least 3 working days before final acceptance demonstration, the contractor shall submit project record drawings of the BAS for approval by the university. If more than three errors or omissions are found during the university review or during the acceptance procedure the acceptance procedure will be cancelled and rescheduled when accurate and complete drawings are received.
2. Project Record Documents shall include all the information in the submittal drawings plus:
a. All communication wiring shall have the exact route shown on a floor plan.
b. Include the working construction drawings set from the installation sub-contractor.
c. Exact locations of all devices including panels, communication devices, IO devices, etc. shall be shown. Construction room numbers if different from the university room numbers do not meet this requirement.
d. All changes made during installation shall be shown.
e. The electrical circuits used by the BAS should be clearly indicated as panel and circuit number.
f. Unit communication address identifiers shall be shown.
g. Conductor and pneumatic tubing identifier numbers.
3. After receiving final approval, supply six (or as specified on Division 1) complete project record drawing sets (maximum ANSI "D" size), together with an electronic copy to the university. The project is not considered complete until record documents have been received and certified complete and accurate by the university.
4. O&M manuals shall be provided that detail any maintenance required for any device in the system.
5. After all punch list, commissioning has been completed, and the before the university accepts the project
a. Run reporting for any unresolved lines for all programming.
b. Run reporting to find any unused points and delete them from the database.
c. Run reporting to find any unused commissioning, trends, reports and unneeded graphics.
d. Run reporting for any database errors in database using the system activity log.
e. Run reporting a network performance diagnostic test and provide report to the university.

3.4 TRAINING

A. Contractor shall provide to the engineer and the university a training class outline prior to any schedule training.

B. The control contractor shall conduct on-site training courses for designated university personnel in the maintenance and operation of the control system.
1. A minimum of one class shall be given upon system acceptance. Classes shall be no longer than four hours in duration and budgeted at 1 hour of training time per 4000 sq. ft. of controlled area in labs and 1 hour per 7500 sq. ft. in office space. A minimum of one four hour class shall be provided.

2. Before training begins the O&Ms shall be complete the project BAS shall be communicating to the campus BAS.
3. Training sessions shall be provided for the university's personnel by factory trained personnel knowledgeable about all aspects of the installation.
4. Training outline shall be coordinated with University Engineering and shall include as a minimum.
    a. Instruction on specific systems and instructions for operating the installed system
    b. A tour of the installation to show the location of all system components
    c. A review of the project documentation.
    d. A review of the sequences of operation.
    e. A review of graphical commanding and alarming.
    f. A review of the troubleshooting procedures
    g. A review of terminal controller operations.
    h. A review of emergency operation due to utility loss (power, chilled water, steam), panel failures, and major mechanical or electrical systems.
    i. A review of the O&Ms and the working construction drawing set from the installation subcontractor.
5. Provide 8 hours total of seasonal loop tuning.

C. The BAS contractor will provide, at no cost to the university, standard training for the operations staff. Such training shall be adequate to fully enable the student to perform any required operating procedures in the BAS.

D. Forty hours of factory training shall be provided for any Lab building over 80,000 sq. ft. Eighty hours of factory training shall be provided for any lab building over 300, 000 sq. ft.

3.5 DEMOLITION

A. Demolition of an existing control system will include removal of controls which do not remain as part of the BAS, all associated abandoned wiring and conduit, and all associated pneumatic tubing.

B. The University Project Manager will inform the BAS Contractor of any equipment which is to be moved that will remain the property of the university. All other equipment which is removed will be disposed of by the BAS Contractor.

C. Existing controls which are to be reused must each be tested and calibrated for proper operation

D. Existing controls which are specified to be reused and are found to be defective requiring replacement will be noted to the University Project Manager. If necessary a change order will be issued to the contractor for repair or replacement of the defective device.

END OF SECTION 23 09 00