

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

### SECTION 25 0800 – BMS TESTING AND COMMISSIONING

Revise this Section by deleting and inserting text to meet Project-specific requirements.

This Section uses the term "Engineer." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

Delete hidden text after this Section has been edited for the Project.

#### PART 1 - GENERAL

##### 1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor's attention is specifically directed, but not limited, to the following documents for additional requirements:
  - 1. The current version of the Uniform General Conditions for Construction Contracts, State of Texas, available on the web site of the Texas Facilities Commission.
  - 2. The University of Houston's *Supplemental General Conditions and Special Conditions for Construction*.

##### 1.02 SUMMARY

- A. Section includes:
  - 1. BMS and equipment testing and Start-up.
  - 2. Validation of proper and thorough installation of BMS and equipment.
  - 3. Functional testing of control systems.
  - 4. Documentation of tests, procedures, and installations.
  - 5. Coordination of BMS training.
  - 6. Documentation of BMS Operation and Maintenance materials.
- B. This Section defines responsibilities of the Contractor to commission the BMS in situations where controls are being replaced on existing equipment but not where core equipment is being replaced.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- C. The term "Owner" shall include a representative from the Owner's Building Management Services but that representative is not expected to represent the Owner exclusively. MEP Engineer may also be authorized to act as Owner's Designated Representative. Coordinate all activities to include all of the Owner's representatives.
- D. Commissioning is the process of ensuring that all building systems are installed and perform interactively according to the design intent; the systems are efficient and cost effective and meet the Owner's operational needs; the installation is adequately documented; and the Operators are adequately trained. It serves as a tool to minimize post-occupancy operational problems. It establishes testing and communication protocols in an effort to advance the building systems from installation to full dynamic operation and optimization.
- E. The Contractor shall direct, coordinate, and oversee the Commissioning process and witness functional performance testing.
- F. The Owner's TAB Firm may write the Owner-approved control sequence verification sheets for functional performance tests and develop forms using the BMS Provider's point log to test each point back to the graphical interface. The BMS Provider shall furnish the Contractor with an estimated time to complete this task, which Contractor will incorporate in the Project Schedule. In the event Owner's TAB Firm is not under contract for the Project, the Contractor shall write the Owner-approved sequence verification sheets for functional performance tests.

### 1.03 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within references.

### 1.04 CONTRACTOR RESPONSIBILITIES

- A. Completely install and thoroughly inspect, startup, preliminarily test, adjust, balance, and document all systems and equipment. The testing and commissioning of the BMS is the responsibility of the BMS installer and Contractor.
- B. Assist Owner, Commissioning Agent and TAB firm in verification and functional performance testing. This assistance will generally include the following:
  - 1. Attend Commissioning progress and coordination meetings.
  - 2. Prepare and submit required draft forms and systems information.
  - 3. Establish trend logs of system operation as specified herein.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

4. Demonstrate system operation.
5. Manipulate systems and equipment to facilitate testing.
6. Provide instrumentation necessary for verification and performance testing.
7. Manipulate control systems to facilitate verification and performance testing.
8. Train Owner as specified in this Section.

Coordinate with UH Project Manager for amount of software optimization required for each project.

- C. Provide a BMS Technician to work at the direction of Owner for software optimization assistance for a maximum of [10][20][40][80][Insert Hours Here] hours. Refer to Part 3 of this Section for a description of the software optimization.

### 1.05 SUBMITTALS

- A. The following list outlines the general sequence of events for submittals and commissioning:
  1. Submit product data and Shop Drawings and receive approval.
  2. Submit BMS logic documentation and receive approval.
  3. Submit background graphic screens and receive approval.
  4. Submit Start-Up Checklists and manufacturer's start-up procedures for all equipment provided by the Contractor.
  5. Install BMS.
  6. Submit BMS Start-Up Test Agenda and Schedule for review.
  7. Receive BMS Startup Test Agenda and Schedule approval.
  8. Submit calibration certifications for verification equipment.
  9. Submit Training Plan.
  10. Simulate sequencing and debug program off-line to the extent practical.
  11. Place systems under BMS control where applicable during a scheduled outage. EHLS personnel shall be present at scheduled Research outages.
  12. Perform BMS Startup during a scheduled outage.
  13. Prepare and initiate trend log data storage and format trend graphs.
  14. Submit completed BMS Start-Up Reports and initial draft of the Operating and Maintenance (O&M) Manuals.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

15. Receive BMS Startup Report approval and approval to schedule Demonstrations and Commissioning.
16. Demonstrate systems to Owner.
17. Submit Trend Logs in electronic format specified.
18. Receive demonstration approval and approval to schedule Acceptance Period, per paragraph 3.07.
19. Train Owner on BMS operation and maintenance.
20. Substantial Completion.
21. Begin Acceptance Phase.
22. Two-week Operational Test.
23. Perform Functional Performance Testing including point to point verification to graphical interface.
24. Receive Acceptance Period approval, which is Functional Completion for the BMS.
25. Train Owner on final sequences and modes of operation.
26. Install framed control Drawings.
27. Provide Level 1 (view only) password access to the Owner.
28. Revise and submit Record Drawings and O&M Manuals.
29. Manager of Building Management Services sign-off required.
30. Provide Admin level access to Owner.
31. Final Acceptance.

Extended Operational Test may not be required for all projects. Consult with UH Project Manager. If Extended Operational Test not required, remove the following two paragraphs.

32. Begin Extended Operational Test.
33. Submit results of Extended Operational Test to Owner and receive acceptance of test results.
34. Begin Warranty Phase.
35. Schedule and begin Opposite Season acceptance period.
36. Receive Opposite Season acceptance period approval.

<Insert A/E Name>  
AE Project #: <Insert Project  
Number>

**BMS Testing and Commissioning**  
**UH Master: 05.2020**

25 0800 - 4

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

37. Submit Record Drawings and O&M Manuals.
38. Update framed control Drawings.
39. Complete Owner (AHJ) Training.
40. End-of-Warranty date/period.

### PART 2 - PRODUCTS

#### 2.01 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

#### 2.02 INSTRUMENTATION

- A. Instrumentation required to verify readings and to test the system and equipment performance shall be provided by Contractor and made available to Owner. Generally, no testing equipment will be required beyond that required to perform Contractor's Work under these Contract Documents. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

#### 2.03 TAB AND COMMISSIONING PORTABLE OPERATORS TERMINAL

- A. For new Projects, Contractor shall provide portable operators terminal or hand-held device to facilitate Testing, Adjusting, and Balancing (TAB) and calibration. This software or device shall support all functions and allow querying and editing of all parameters required for proper calibration and Start-up.
- B. Connections shall be provided local to the device being calibrated. For instance, for VAV terminal units, connection of the operator's terminal shall be either at the sensor or at the terminal unit. Otherwise a wireless system shall be provided to facilitate this local functionality.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

### 3.02 BMS START-UP TESTING, ADJUSTING, CALIBRATION

A. Work and/or systems installed under this Division shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this Contract, as described below:

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages and verify that all circuits are free from faults.

[Edit below for retrofit projects.](#)

3. Verify integrity/safety of all electrical connections. **[For the following control settings, initially use the control setting that was used by existing control system, unless otherwise indicated. For AHUs that use a throttled outside air damper position when minimum outside air is required, Contractor shall mark existing minimum outside air damper position to allow replication by new controls.]**
4. Before any testing, adjusting, or balancing work commences, vendor must submit a graphics screens package to Owner for approval.
5. Coordinate with Owner's TAB Firm to obtain and Owner's CxA to fine-tune control settings that are determined from balancing procedures. Record the following control settings as obtained from Owner's TAB Firm, and note any TAB deficiencies in the BMS Start-Up Report:
  - a. Optimum duct static pressure setpoints for VAV air handling units.
  - b. Minimum outside air damper settings for air handling units.
  - c. Optimum differential pressure setpoints for variable speed pumping systems.
  - d. Calibration parameters for flow control devices such as VAV terminal units and flow measuring stations.
    - 1) Contractor shall provide hand-held device as a minimum to the TAB Firm to facilitate calibration. Connection for any given device shall be local to it (i.e. at the VAV terminal unit or at the thermostat). Hand-held device or portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start-up.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

6. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BMS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range). Record the measured value and displayed value for each device in the BMS Start-up Report.
7. Check and set zero and span adjustments for all transducers and transmitters.
8. For dampers and valves:
  - a. Check for adequate installation including free travel throughout range and adequate seal.
  - b. Where loops are sequenced, check for proper control without overlap.
9. For actuators:
  - a. Check to ensure that device seals tightly when the appropriate signal is applied to the operator.
  - b. Check for appropriate fail position, and that the stroke and range is as required.

Remove paragraph below if there are no pneumatic actuators in the project.

- c. For pneumatic operators, adjust the operator spring compression as required to achieve close-off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split-range positioners to verify proper operation. Record settings for each device in the BMS Pre-Commissioning Report.
  - d. For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.
10. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the Operator Interface display. Record the results for each device in the BMS Start-Up Report.
11. For outputs to reset other manufacturer's devices (for example, VSDs) and for feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

12. Verify proper sequences by using the approved checklists to record results and submit with BMS Start-Up Report. Verify proper sequence and operation of all specified functions.
13. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.

Engineer shall provide the tolerances for the type and criticality of the area or zone being served by the equipment. Engineer may have to specify two or more sets of tolerances for a specific Project. Edit accordingly.

14. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BMS Start-up Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):
  - a. Duct air temperature:  $[\pm 1 \text{ degrees F}]$ .
  - b. Space Temperature:  $[\pm 1 \text{ degrees F within 30 minutes}]$ .
  - c. Chilled Water:  $[\pm 1 \text{ degrees F}]$ .
  - d. Hot water temperature:  $[\pm 3 \text{ degrees F}]$ .
  - e. Duct pressure:  $[\pm 0.25 \text{ inches wg}]$ .
  - f. Water pressure:  $[\pm 1 \text{ psid}]$ .
  - g. Duct or space Humidity:  $[\pm 5 \text{ percent within 30 minutes}]$ .
  - h. Air flow control:  $[\pm 5]$  percent of **[setpoint velocity][true airflow]**.
  - i. Space Pressurization (on active control systems):  $[\pm 0.05 \text{ inches wg}]$  with no door or window movements.
15. For interface and DDC control panels:
  - a. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the Record Drawings.
  - b. Ensure that terminations are safe, secure and labeled in accordance with the Record Drawings.
  - c. Check power supplies for proper voltage ranges and loading.



## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- d. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
  - e. Check for adequate signal strength on communication networks.
  - f. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
  - g. Ensure that all outputs and devices fail to their proper positions/states.
  - h. Ensure that buffered and/or volatile information is held through power outage.
  - i. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
  - j. Check for proper grounding of all DDC panels and devices.
16. Low voltage and high voltage wiring must not be housed in the same conduit. BMS wiring and fire alarm wiring must not be housed in the same conduit. For Operator Interfaces:
- a. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
  - b. Output all specified BMS reports for review and approval.
  - c. Verify that the alarm printing and logging is functional and per requirements.
  - d. Verify that trends are archiving to disk and provide a sample to the Owner for review. Analog trends are not acceptable
  - e. Verify that paging/dial-out alarm annunciation is functional and issues email notification. IP address will be provided by Owner.
  - f. Verify the functionality of remote Operator Interfaces and that a robust connection can be established consistently.
  - g. Verify that required third party software applications required with the bid are installed and are functional.
  - h. Start-up and check out control air compressors, air drying, and filtering systems in accordance with the appropriate Section and with manufacturer's instructions.
  - i. Verify proper interface with fire alarm system.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- B. Submit Start-Up Test Report: Report shall be completed, submitted, and approved **prior** to Substantial Completion.

### 3.03 SENSOR CHECKOUT AND CALIBRATION

- A. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2 degrees F of each other for temperature and within a tolerance equal to 2 percent of the reading of each other for pressure. Tolerances for critical applications may be tighter.
- B. Calibration: Calibrate all sensors using one of the following procedures:
  - 1. Sensors without Transmitters - Standard Application: Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gauge or BMS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20 percentage of the expected range.
  - 2. Sensors with Transmitters - Standard Application: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BMS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until the ammeter reads 4 mA. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or BMS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator. NOTE: when a sensor is disconnected, it shall not display old data (no "frozen in time" data).
- C. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 25 1100 "BMS Basic Materials, Interface Devices, and Sensors."

### 3.04 COIL VALVE LEAK CHECK

- A. Verify proper close-off of the valves. Ensure the valve seats properly seat by simulating the maximum anticipated pressure difference across the circuit. Demonstrate to the Owner the verification of zero flow by measuring the coil differential pressure. If there is pressure differential, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

<Insert A/E Name>  
AE Project #: <Insert Project  
Number>

**BMS Testing and Commissioning**  
**UH Master: 05.2020**

25 0800 - 10

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

### 3.05 VALVE STROKE SETUP AND CHECK

- A. For all valve and actuator positions checked, verify the actual position against the Operator Interface readout.
- B. Set pumps to normal operating mode. Command valve closed: verify that valve is closed and adjust output zero signal as required. Command valve open: verify position is full open and adjust output signal as required. Command the valve to various few intermediate positions. If actual valve position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

### 3.06 BMS DEMONSTRATION

- A. All BMS Demonstration shall take place on the main Control Systems Server and UNIVERSITY OF HOUSTON WAN. Schedule to add system to main Control Systems Server and UNIVERSITY OF HOUSTON WAN with Owner at least two (2) weeks in advance of the demonstration. At the time of request, provide all documentation that the following criteria are met:
  - 1. Updated BMS submittals in electronic and hard copy to Owner including the updated riser diagram for the system.
  - 2. Reports on verification of Network Layout Verification including but not limited to Building Controller locations, cable routes with length of cable between controllers and any trunk extenders or trunk isolators.
  - 3. Reports on verification of electrical characteristics of BMS network, communications and electrical integrity of Building Controllers.
  - 4. Reports on verification of traffic on BMS Network including but not limited to COVs between Building Controllers, point commands by the operator, point commands by program across the network, alarm reporting on the network, any unresolved points in the system, integrity of the ports on any Building Controller isolator/extender and results of Building Controller tests running at selected baud rate.
  - 5. Demonstrate to Owner the updates of databases without errors or faults between the temporary Control Systems Server and Building Controllers. If there is no temporary server, demonstrate to Owner after system is added to main Control Systems Server.
  - 6. Reports on verification of system log files, interruption of log files of system traffic and overall acceptable operation of the system where a temporary Control Systems Server is utilized.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- B. Demonstrate the operation of the BMS hardware, software, and all related components and systems to the satisfaction of the Owner. Schedule the demonstration with the Owner seven (7) calendar days in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report, are approved. If the Work fails to conform to the Contract Documents, Contractor shall schedule an additional Site visit with the Owner for re-demonstration.
- C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and HVAC systems. Either qualified or certified technician acting as the company's SME are required to facilitate the operations of the system's performance. All training documentation and submittals shall be maintained at the Project Site.
- D. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner.
- E. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
  - 1. Demonstrate that required software is installed on BMS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
  - 2. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
  - 3. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.
  - 4. Demonstrate correct calibration of input/output devices using the same methods specified for the Start-Up Tests. A maximum of 10 percent of I/O points shall be selected at random by the Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by Owner for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
  - 5. Demonstrate that all DDC and other software programs exist at respective field panels. The Direct Digital Control (DDC) programming and point database shall be as submitted and approved.
  - 6. Demonstrate that all DDC programs accomplish the specified sequence of operation.
  - 7. Demonstrate that the panels and DDC network of panels automatically recover from power failures within five (5) minutes after power is restored.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

8. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
  9. Identify access to equipment selected by the Owner. Demonstrate that access is sufficient to perform required maintenance.
  10. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
- F. BMS Demonstration shall be completed and approved prior to Substantial Completion.
- G. Any tests successfully completed during the demonstration will be recorded as passed for the functional performance testing and will not have to be retested.

### 3.07 BMS ACCEPTANCE PERIOD

- A. After approval of the BMS Demonstration and prior to Contract Close-out, the Acceptance Phase shall commence. Acceptance Period shall not be scheduled until all HVAC systems are in operation and have been accepted, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, and the like), and TAB report has been submitted and approved. Acceptance Period and its approval may be performed on a system-by-system basis if mutually agreed by the Contractor and Owner.
- B. Operational Test: At the beginning of the Acceptance Phase, the system shall operate properly for two (2) weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these Specifications. At the end of the two weeks, Contractor shall forward the trend logs to the Owner for review. Owner shall determine if the system is ready for functional performance testing and document any problems requiring Contractor's attention.
1. If the systems are not ready for functional performance testing, Contractor shall correct problems and provide notification to the Owner that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one-week period.
  2. This process shall be repeated until Owner issues notice that the BMS is ready for functional performance testing.
- C. During the Acceptance Period, the Contractor shall maintain a hard copy log of all alarms generated by the BMS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

For retrofit projects, leave paragraph below. Remove for new construction.

### 3.08 BMS WHOLE BUILDING TEST

- A. Prior to any demolition and installation, Contractor shall verify that existing Building Management System operates as intended. Contractor shall test all thermostats, DDCs, sensors, actuators etc. to verify proper operation. Contractor shall monitor BMS for fourteen (14) days prior to demolition to serve as the baseline for the BMS. Provide report to Owner with any deficiencies clearly stated.
- B. Once installation and testing of BMS is complete, the Contractor shall demonstrate to the Owner that the building-wide BMS is functioning in a similar fashion as before any additions or modifications to the BMS were made. Any systems not operating as before shall be modified, at no extra cost to the Owner, to operate as intended and as documented to operate before construction.
- C. Building wide BMS shall be operated for a minimum of fourteen (14) days after Acceptance Testing. Any deficiencies found that differ from the existing condition shall be corrected.

Discuss with UH project manager whether Extended Operation Test is required. Extended operation test will increase project cost.

### 3.09 BMS EXTENDED OPERATION TEST

- A. Extended operation test is intended to simulate normal operation of BAS by Owner.
- B. Operate BAS for an operating period of [21][42] consecutive calendar days following BMS Acceptance Test and Substantial Completion. Coordinate exact start date of testing with Owner.
- C. Provide an operator familiar with BAS installed to man an operator workstation while on-site during eight hours of each normal business day occurring during operating period.
- D. During operating period, BAS shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
- E. BMS Operator shall be able to correct defects as issues occur.
- F. Definition of failures shall be defined as any control point unable to perform as intended due to hardware, software or any other means. Amount of time the control point is failed shall be logged. Failures due to power outages outside of the scope of the BMS shall not count as downtime.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- G. During test, log downtime and operational problems as they occur. Maintain a log that identifies the source of the problem, description of any corrective actions, time of occurrence and duration of downtime. Log shall be available for Owner's review at any time.
- H. For BAS to pass extended operation test, total downtime shall not exceed 1 percent of total point-hours during operating period. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until BAS passes requirement.
- I. For evaluation of BAS passing test, the total time shall be calculated by the number of points multiplied by the total number of hours during operating period. The downtime shall be calculated by multiplying the total number of failed points by the time each point was failed.
- J. Provide test reports to Owner at completion of testing.

### 3.10 TREND LOGS

- A. Contractor shall configure and analyze all trends required under Section 25 1500 "BMS Software and Programming".

### 3.11 TREND GRAPHS

- A. Trend graphs as specified in Section 25 1500 "BMS Software and Programming" shall generally be used during the Acceptance Phase to facilitate and document testing. Prepare controller and workstation software to display graphical format trends during the Acceptance Period. Trend graphs shall demonstrate compliance with Contract Documents.
- B. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.

### 3.12 SOFTWARE OPTIMIZATION ASSISTANCE

- A. The Contractor shall provide the services of a BMS Technician as specified above at the Project Site to be at the disposal of the Owner to make minor modifications to the Building Management System. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the Owner during the construction and commissioning of the Project and that are not identified in the Contract Documents. The cost for this service shall be included with the bid at a stated hourly rate. Requests for assistance shall be for non-consecutive 8-hour days, unless otherwise mutually agreed upon by Contractor and Owner. The Owner shall notify Contractor five (5) days in advance of each day of requested assistance. Refer to Part 1 of this Section for additional requirements.
- B. A BMS Technician shall be available for software optimization, at minimum, at regularly scheduled intervals following the schedule below. The Owner shall request software optimization in writing or email.
  - 1. Completion of Operational Acceptance Testing.

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

2. Ninety (90) days after Operational Acceptance Testing.
  3. Six (6) months after Operational Acceptance Testing.
  4. Nine (9) months after Operational Acceptance Testing.
  5. One year after Operational Acceptance Testing.
- C. The BMS Technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BMS Technician provided cannot perform every software task requested by the Owner in a timely fashion, Contractor shall provide additional qualified personnel at the Project Site as requested by the Owner, to meet the total specified requirement on-Site. Coordinate training requirements with Owner's Monitoring Services Department.

### 3.13 BMS OPERATOR TRAINING AND O&M MANUALS

- A. Provide up to four (4) complete sets of the approved Operations and Maintenance (O&M) Manuals (hard copy and one electronic copy) to be used for training.
- B. Contractor shall submit a Training Plan for the scope of training for which BMS Provider is responsible. Training Plan shall be forwarded to the Contractor who will compile, organize, format, and forward to the Engineer for review.
  1. Coordinate requirements of Training with the Owner's Monitoring Services Department.

The Engineer shall carefully coordinate the training requirements with the needs of Owner's facilities staff. Expansions of existing systems obviously require less training than new systems. The following generally outlines an on-Site training session. The more advanced training may be better provided off Site on a case-by-case basis. Edit to suit Project.

- C. On-Site Training: Provide services of BMS Provider's qualified technical personnel for **[five (5)][ten (10)]** 8-hour days to instruct Owner's personnel in operation and maintenance of BMS. Instruction shall be in classroom setting at the Project Site for appropriate portions of the training. Training may be in non-contiguous days throughout the warranty period at the request of the Owner. The Owner shall notify Contractor seven (7) calendar days in advance of each day of requested training. The Contractor's designated certified trainer proficient in the system being installed shall meet with the Engineer and Owner to discuss and fine-tune the training agenda prior to the first training session. Training shall be video recorded in re-playable electronic format. Training agenda shall generally be as follows:
1. Basic Operator Workstation (OWS) Training – For all potential users of the OWS:
    - a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.



## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

- b. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation Drawings, and DDC programming documentation.
  - c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
  - d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
  - e. Overview of systems installed.
  - f. Present all Site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the BMS.
  - g. Overview of alarm features.
  - h. Overview of trend features.
  - i. Overview of workstation reports.
2. BMS Hardware Training – For Maintenance and Control Technicians:
    - a. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
  3. BMS Technician Training:
    - a. Introduction to controller programming and overview of the programming application interface.
    - b. General review of sequence of operation and control logic for the Project Site, including standalone and fail-safe modes of operation.
    - c. Uploading/Downloading and backing up programs.
    - d. Network administration.
    - e. Review of setpoint optimization and fine-tuning concepts.

Coordinate requirements of Training with the Owner's Monitoring Services Department to determine if Off-Site Training is required for the Project. Edit accordingly.

- D. Off-Site Advanced Training:

## University of Houston Master Specification

<Insert Project Name>  
<Insert U of H Proj #>

<Insert Issue Name>  
<Insert Issue Date>

1. Advanced Training shall be provided at any time during the Warranty Period for **[two]** individuals in Owner's employ and shall be provided at the manufacturer's off-Site training facility containing installations of the specified system. Contractor shall pay training registration, materials, and miscellaneous fees. The Owner shall pay for all expenses for travel (transportation, meals, lodging, etc.).
  - a. Advanced training shall include the standard, advanced training offered on all Control Programming Applications for the system installed.
  - b. Advanced training shall include the standard, advanced training offered on Advanced Installation, Configuration, Maintenance, and Network Administration.

### 3.14 WARRANTY PHASE BMS OPPOSITE SEASON TRENDING AND TESTING

- A. Trending: Throughout the Warranty Phase, trend logs shall be maintained. Contractor shall forward archive trend logs to the Owner for review upon Owner request. Owner will review these and notify Contractor of any warranty work required.
- B. Opposite Season Testing: Within twelve (12) months of Substantial Completion, Contractor shall schedule and conduct, with Owner, Opposite Season functional performance testing. BMS Provider shall participate in this testing and remedy any deficiencies identified.

END OF SECTION 25 0800