
PART 1 - GENERAL

1.1 WORK OF THIS SECTION

- A. This section of the specifications details the components to be provided by the BMCS subcontractor relating to the following:
 - 1. BMCS Mockup.
 - 2. Tri-path AHU Mockup.
 - 3. Unitary Controller Compatibility Test for Fan Powered Terminal Units.
 - 4. Testing and Inspections.
 - 5. Inspection During Installation.
 - 6. Point to Point Verification.
 - 7. Calibration.
 - 8. Acceptance Testing.

1.2 SCHEDULING

- A. Acceptance testing shall comply with the Construction Contract schedule. Corrections or alterations, which have been noted during the acceptance tests, shall be completed prior to the end date called for in the Construction Contract.

1.3 TESTING AND INSPECTIONS - GENERAL

- A. All components shall be tested by the BMCS subcontractor to ensure compliance with the specifications before they leave the BMCS subcontractor's premises and shall be tested again on-site by the BMCS subcontractor before the commencement of acceptance testing. The BMCS subcontractor shall not ship components to the project site until they have been found to be fully compliant with the specifications and the BMCS subcontractor shall not request the commencement of acceptance testing until such time as a complete and thorough checkout of all equipment has been made by the BMCS subcontractor.
- B. Any component furnished under this contract shall be made available for inspections or tests, as deemed necessary by the Owner and/or Consultant. Use of any component by the Owner shall not imply acceptance of the system or acceptability of any component. Availability and demonstration of the systems shall not be withheld and the use of components shall not imply the start of the warranty period.
- C. Costs associated with the required inspections and testing shall be included in this scope of work. Additional charges will not be accepted.

1.4 DATE OF COMPLETION AND TESTING OF SYSTEMS

- A. The date for the final performance and acceptance testing shall comply with the Schedule and shall be sufficiently in advance of the time(s) of completion to permit the execution of the testing by the Subcontractor prior to occupancy and the closeout of the Construction Contract. Any adjustments and/or alterations, which the final acceptance tests indicate as necessary for the proper and satisfactory functioning of all equipment and systems, shall be completed prior to the closeout of the Construction Contract. Retests shall not relieve the Subcontractor of completion date responsibility.

PART 2 - PRODUCTS

2.1 BMCS MOCKUP

- A. Provide a mockup of select components and features of the BMCS during the early stages of construction. The BMCS mockup shall be constructed at the BMCS subcontractor's facilities and remain intact as long as necessary to obtain the Consultant and Owner approvals.
- B. The BMCS mockup shall include, at minimum, the following hardware components:

1. Primary and Backup NDS.
 2. All OIW.
 3. All ROW.
 4. All HHD.
 5. Partial MLAN.
 6. At least four CCP on the project in the final panel enclosure.
 7. Select FLAN to support the DCP/UC listed below.
 8. DCP, mounted in the final panel enclosures, serving the following systems:
 - a. Lower and Upper Loop CHW Plant.
 - b. Condenser Water System and associated Water Treatment System.
 - c. Lower and Upper Loop Heating Hot Water System.
 - d. Typical Floor Tri-Path AHU (AHU-30-1 and AHU-30-2).
 - e. Typical Floor Overhead VAV AHU (AHU-5-1 and AHU-5-2).
 - f. Toilet Exhaust System.
 - g. Typical Fan Coil Unit.
 - h. Typical Fan Coil Unit with Outside Air.
 - i. Lobby AHU.
 - j. Radiant Floor System.
 - k. Service Elevator Lobby AHU.
 9. UC serving the following systems:
 - a. All FPTU UC associated with the typical floor AHU above for one floor.
 - b. The UC serving CAVTU for toilet exhaust on the one typical floor.
 10. One FPTU shall be provided by the Mechanical subcontractor for the BMCS mockup.
 11. One CAVTU shall be provided by the Mechanical subcontractor for the BMCS mockup.
 12. One VFD shall be provided by the Mechanical subcontractor.
 13. Two Lighting Control Relay Panels and associated communication gateway are to be provided. One Lighting Control Relay Panel shall be configured for the garage and one shall be configured for the exterior, lobby, and typical office level.
 14. Any temporary power required for the BMCS mockup including components provided by the Mechanical or Electrical subcontractor shall be provided by the BMCS subcontractor.
 15. Actuators and sensors associated with the above systems are not required as part of the mockup.
- C. Provide a software based I/O point operational simulator to confirm proper operation of each type of I/O configuration.
- D. The BMCS mockup shall include, at minimum, the following software components:
1. All NDS. OIW, ROW, HHD, one WAP, and all operator software required by Section 25 11 00 for the entire BMCS.
 2. All monitoring and control software including system graphics required by Section 25 15 00 for the entire BMCS. The graphics required for each system shall be created. Repetitive graphics for identical units are not required.
 3. All operating sequences of operation software required by Section 25 80 00 for the systems listed above.
 4. Software interface to the VFD.
 5. Software interface to the Lighting Control Relay Panels.
- E. Provide demonstration of the above components, software and operating features to the Owner, Consultant and General Contractor in a BMCS Mockup Review Session. It is anticipated that each feature and function of the hardware and software will be reviewed over a one week period. The Consultant will create a Deficiency List from the BMCS Mockup Review Session. The BMCS subcontractor shall correct all deficiencies noted and a follow up BMCS Mockup review session will be schedule.
- F. If there are deficiencies remaining after the initial BMCS mockup demonstration that require further testing by the Consultant, then the expenses of the Owner and Consultant incurred in providing the additional follow-up tests to verify compliance with the specifications, including travel, subsistence, accommodation and normal consulting fees, shall be paid by the BMCS subcontractor at no additional cost to the Owner.

2.2 TRI-PATH AHU MOCKUP

- A. Provide a mockup of all components and features of the tri-path AHU during the early stages of construction. The AHU mockup shall be constructed at an Owner approved testing facility for sound and performance testing by the Mechanical Subcontractor. This same unit shall be used for the BMCS mockup testing. The AHU mockup shall remain intact as long as necessary to obtain the Consultant and Owner approvals.
- B. The AHU mockup shall include, at minimum, the following hardware components:
1. One ROW. The BMCS Contractors ROW may be utilized in lieu of the ROW provided for the project for the AHU Mockup.
 2. Partial MLAN and FLAN to support the ROW, DCP, and software interface to the VFD.
 3. One CCP on the project in the final panel enclosure.
 4. DCP mounted in the final panel enclosures for the AHU.
 5. VFD shall be provided by the Mechanical subcontractor.
 6. All actuators and sensors associated with the AHU.
- C. The AHU mockup shall include, at minimum, the following software components:
1. All monitoring and control software including system graphics required by Section 25 15 00 for the AHU.
 2. All operating sequences of operation software required by Section 25 80 00 for the AHU.
 3. Software interface to the VFD.
- D. Provide a complete shop drawing for the AHU mockup using the approved end devices. Submit the shop drawing to the consultant for approval prior to mockup installation.
- E. The AHU mockup shall include physical inspection of the following:
1. Inspect installation of damper actuators on the unit. Verify rigid installation. Observe full open to full close stroking of actuator motor without binding.
 2. Inspect installation of valve actuators on the unit. Verify rigid installation. Observe full open to full close stroking of actuator motor without binding.
 3. Inspect installation of conduit, cabling, and sensor tubing from the DCP to end devices.
 4. Inspect mounting of CCP, DCP, and associated instrumentation within panel enclosures. Verify accessibility for service after installation.
- F. Air Flowrate Sensor Performance:
1. Verify the accuracy of the multipoint flow sensor is within specification tolerances at various primary air positions between the minimum and maximum ranges of the outside air for the AHU and overhead zones for the AHU. Use at least six damper positions (lab reading vs. controller reading vs. damper position). Chart this performance on a table indicating accuracy deviations and also chart on a graph (cfm vs. % damper position) indicating lab and controller readings on the same graph.
 2. Verify the controller operation is stable at low flow inlet conditions (less than the multipoint flow sensor rated accuracy limit). Record minimum inlet velocity at which accurate sensor accuracy and control was maintained.
- G. DCP Electrical Performance:
1. Reduce the input voltage on the DCP to below 85% for an extended period. Note if controller performance is affected.
 2. Reduce the input voltage on the DCP slowly to witness at what voltage the DCP will shut down and verify that the shutdown was orderly.
 3. Increase the input voltage on the DCP slowly to witness at what voltage the DCP will re-enable itself and verify that the restart was orderly.
 4. Verify that during the operation of the DCP, electrical noise is not induced back into the electrical system. This shall require an oscilloscope.
- H. Provide demonstration of the above components, software and operating features to the Owner, Consultant and General Contractor in an AHU Mockup Review Session. It is anticipated that each feature and function of the hardware and software will be reviewed over a one week period. The Consultant will create a Deficiency List from the AHU Mockup Review Session. The BMCS subcontractor shall correct all deficiencies noted and a follow up AHU Mockup review session will be corrected during the AHU Mockup Review Session.

- I. If there are deficiencies remaining after the initial AHU mockup demonstration related to the BMCS that require further testing by the Consultant, then the expenses of the Owner and Consultant incurred in providing the additional follow-up tests to verify compliance with the specifications, including travel, subsistence, accommodation and normal consulting fees, shall be paid by the BMCS subcontractor at no additional cost to the Owner.

2.3 UNITARY CONTROLLER COMPATIBILITY TEST FOR FAN POWERED TERMINAL UNITS

- A. Provide the following terminal unit compatibility testing for each type of fan powered terminal unit to be utilized on the project. Terminal unit testing shall include the following procedures conducted and documented by an Owner approved testing facility. Testing shall be completed and documented prior to bid submittal.
- B. Physical Inspection:
 1. Inspect installation of damper actuator on the unit. Verify rigid installation. Observe full open to full close stroking of actuator motor without binding.
 2. Inspect installation of cabling and sensor tubing from the Unitary Controller (UC) to end devices.
 3. Inspect mounting of controller on unit. Verify accessibility for service after installation.
- C. UC Flowrate Performance:
 1. Verify all UC software parameters are provided to meet the specifications.
 2. Verify the ability to shut down and turn on the fan.
 3. Verify the ability to start and stop the fan and adjust the fan flowrate setpoint via interface to the ECM+ motor.
 4. Verify the ability to provide complete shut off of the primary air cooling damper.
 5. Verify the accuracy of the multipoint flow sensor is within specification tolerances at various primary air positions between the minimum and maximum ranges of the terminal unit. Use at least six damper positions (lab reading vs. controller reading vs. damper position). Chart this performance on a table indicating accuracy deviations and also chart on a graph (cfm vs. % damper position) indicating lab and controller readings on the same graph.
 6. Move the flexible primary air duct inlet (simulate a kink in the flexible ductwork) to verify there is not a requirement for straight lengths of ductwork to maintain primary air flowrate sensor accuracy.
 7. Verify the controller operation is stable at low flow inlet conditions (less than the multipoint flow sensor rated accuracy limit). Record minimum inlet velocity at which accurate sensor accuracy and control was maintained.
 8. If cold primary air is available in a controlled and conditioned space, verify that the controller can maintain space conditions at + or - 0.5 Deg. F. around the setpoint.
 9. Set the primary air damper to maintain a fixed flowrate setpoint. Vary the inlet static pressure from 0.1 to 1.5 inches w.g. in 0.2 inches w.g. upward increments. Record the flowrate setpoint, UC controller reading of primary air flowrate, and the laboratory reading at each setpoint. Vary the inlet static pressure from 1.5 to 0.1 inches w.g. in 0.2 inches downward increments noting the same readings. Plot the performance of this test to verify lack of hysteresis effects. Perform this test at minimum and maximum primary air cooling flowrate setpoints.
 10. Verify operating sequence from full cooling to full heating and in reverse.
- D. UC Electrical Performance:
 1. Reduce the input voltage on the UC to below 85% for an extended period. Note if controller performance is affected.
 2. Reduce the input voltage on the UC slowly to witness at what voltage the UC will shut down and verify that the shutdown was orderly.
 3. Increase the input voltage on the UC slowly to witness at what voltage the UC will re-enable itself and verify that the restart was orderly.
 4. Verify that during the operation of the UC, electrical noise is not induced back into the electrical system. This shall require an oscilloscope.

2.4 TESTING OF SOFTWARE INTERFACES

- A. The BMCS subcontractor shall develop and fully test all software required for the interface between the BMCS and equipment furnished by others, as detailed in the BMCS Software Interfaces section of these specifications, prior to the delivery of the associated hardware and software components to the project site. There shall be no software development on site except that associated with the entry of database items such as setpoints, alarm limits and schedules.
- B. The software interfaces shall be fully demonstrated to the Owner and Consultant at an Owner approved location prior to the installation of any related BMCS components at the project site. The demonstration shall include all hardware and software components associated with the interfaces.

2.5 INSPECTION DURING INSTALLATION

- A. Prior to acceptance testing, the BMCS shall be available for use by the Owner. Use by the Owner shall not imply acceptance of any component of the BMCS or the commencement of the warranty period.
- B. Provide staff to assist the Owner/Consultant/Engineer with inspections made during the installation period that are required to review the progress and quality of ongoing work. The Owner/Consultant/Engineer will generate Field Observation Reports on the findings of the inspections. The Owner/Consultant/Engineer shall advise the BMCS subcontractor during the inspection of any concerns noted with respect to the installation and shall report the concerns in writing as soon as possible after the inspection is completed. The BMCS subcontractor shall take corrective action to meet the requirements of the specifications.
- C. Provide a written response to the Field Observation Report within two weeks or receipt of the report to acknowledge any corrective action needed and a proposed schedule for remedy of deficient or items to be corrected.
- D. Failure of the Owner/Consultant/Engineer to identify any error or omission during inspections shall not relieve the BMCS subcontractor of any of the specification requirements and shall not imply that a deviation from the specification has been accepted.

2.6 POINT TO POINT VERIFICATION

- A. Prior to the scheduling of the functional testing, the BMCS subcontractor shall perform a complete and detailed operational check of each BMCS component. Test results shall be documented using test sheets. The test sheets shall be prepared in an appropriate format for the various categories of component to be tested. The format of the test forms shall be submitted for approval during the shop drawing phase of the project and shall be based on the following format:

Point Name	Point Type	Installation Inspected	Point To Point	Full stroke and Modulation	BMCS Value	Instrument Value	BMCS Offset	Accepted	Technician Initials

- B. Submit details of the instrumentation used for the point-to-point checkouts and certification and documentation of calibration.

2.7 CALIBRATION

- A. Provide calibration for all sensors not reporting to the BMCS within the specified accuracies. Provide calibration, adjustment, or replacement in accordance with the following:
 1. Temperature:

- a. Sensors within specified accuracy tolerances do not require sensor calibration or software offset.
 - b. Sensors between specified accuracy and two hundred percent of specified accuracy shall be calibrated or replaced.
 - c. Sensors over two hundred percent of specified accuracy shall be replaced.
2. Humidity:
- a. Sensors within specified accuracy tolerances do not require sensor calibration or software offset.
 - b. Sensors between specified accuracy and two hundred percent of specified accuracy shall be calibrated or replaced.
 - c. Sensors over two hundred percent of specified accuracy shall be replaced.
3. Pressure:
- a. Sensors within specified accuracy tolerances do not require sensor calibration or software offset.
 - b. Sensors between specified accuracy and two hundred percent of specified accuracy shall be calibrated or replaced.
 - c. Sensors over two hundred percent of specified accuracy shall be replaced.
4. Flowrate:
- a. Sensors within specified accuracy tolerances do not require sensor calibration or software offset.
 - b. Sensors between specified accuracy and two hundred percent of specified accuracy shall be calibrated or replaced.
 - c. Sensors over two hundred percent of specified accuracy shall be replaced.

2.8 ACCEPTANCE TESTING

- A. Prior to the scheduling of the acceptance testing with the Owner/Consultant/Engineer, the BMCS subcontractor shall perform a complete and detailed operational check of each BMCS component. Test results shall be documented using test sheets. The test sheets shall be prepared in an appropriate format for the various categories of component to be tested.
- B. Test sheets shall be developed for point-by-point verifications and for a system-by-system operational verification and shall be submitted for approval prior to use.
- C. Completed test sheets indicating the test results for each BMCS component within the system shall be submitted to the Consultant, together with a proposed schedule for acceptance testing prior to the proposed acceptance testing. The Owner and Consultant shall determine on the basis of the BMCS subcontractor's documented testing, whether or not it is appropriate to commence acceptance testing. It shall be the Consultant's decision as to whether the acceptance testing can proceed as proposed by the BMCS subcontractor or whether deficiencies have to be remedied before the acceptance testing can proceed.
- D. Installation, engineering, software and system personnel shall be available on-site during the acceptance test. These personnel shall be familiar with the installation and shall undertake all tests as requested by the Owner and Consultant in order to verify that the BMCS components individually and in total meet the specifications. The BMCS subcontractor shall provide any equipment necessary to undertake testing including, radios, portable computers, metering devices, electric or pneumatic test equipment, and ladders.
- E. Deficiencies witnessed by the Consultant shall be indicated on a "punch-list". Lack of notation of a deficient item by the Consultant does not relieve the subcontractor from compliance with all contract document requirements. The deficiencies shall be corrected and a time of follow-up testing shall be scheduled. If there are deficiencies remaining after the follow-up testing that require further testing by the Consultant, then the expenses of the Owner and Consultant incurred in providing the additional follow-up tests to verify compliance with the specifications, including travel, subsistence, accommodation and normal consulting fees, shall be paid by the BMCS subcontractor at no additional cost to the Owner.
- F. The BMCS subcontractor shall participate and assist in all inspections by the City and Authority Having Jurisdiction and all Mechanical, Electrical, and BMCS acceptance testing as necessary. Testing may take place after normal business hours as required by the project schedule.

- G. The BMCS subcontractor shall participate and assist in all inspections and all Mechanical, Electrical, and BMCS commissioning by the Commissioning Authority as necessary. Testing may take place after normal business hours as required by the project schedule.

END OF SECTION