

SECTION 019113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.

1.3 DEFINITIONS

- A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.
- B. CxA: Commissioning Authority.
- C. FPT: Functional Performance Test.
- D. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- E. PFPT: Prefunctional Performance Test.
- F. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.4 INFORMATIONAL SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, prestart, and startup activities.

1.5 DOCUMENTATION PROCEDURES

- A. Summary:
 - 1. Action & Informational Submittals will be transmitted to the Commissioning Team in electronic (PDF) format using CxA's transmittal system.
 - 2. Construction activities such as RFIs, Punch Lists, Bulletins, Daily Logs, Field Reports, etc. will be transmitted to the Commissioning Team in electronic (PDF) format using CxA's transmittal system.
- B. Procedures:
 - 1. The Commissioning Team shall use an online web based commissioning system selected by the CxA for transmitting the following commissioning activities in electronic (PDF) format:
 - a. Construction Checklist Log
 - b. Issues/Corrective Action Log
 - c. Field Reports
 - d. Progress Photos
- C. Costs:
 - 1. The CxA shall include the full cost of the online web based commissioning system subscription in their proposal.
 - 2. Training shall be included of the online web based commissioning system, with the Commissioning Team.

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1.6 COMMISSIONING SPECIALISTS (CxA)

- A. Subject to compliance with requirements, available commissioning specialists that may be engaged include the following:
 1. dbHMS Design Build Engineering
 2. Synergy Consulting Engineers

1.7 COMMISSIONING TEAM

- A. Members Appointed by Contractor: Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The Commissioning Team shall consist of, but not be limited to, representatives of contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- B. Members Appointed by Owner:
 1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the Commissioning Team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 2. Representatives of the facility user and operation and maintenance personnel.
 3. Design Team: Architect and engineering design professionals.

1.8 OWNER'S RESPONSIBILITIES

- A. Assign operation and maintenance personnel and schedule them to participate in Commissioning Team activities.
- B. Provide access to and parking (including permits) for the CxA, on or near construction site.

1.9 CONTRACTOR'S RESPONSIBILITIES

- A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Evaluate performance deficiencies identified in PFPT & FPT reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
 2. Cooperate with the CxA for resolution of issues recorded in the Issues/Corrective Action Log.
 3. Attend Commissioning Team meetings held on a weekly basis.
 4. Attend coordination and review meetings identified in the construction verification and acceptance phases.
 5. Review and accept construction checklist logs provided by the CxA.
 6. Review and accept commissioning process PFPT & FPT procedures provided by the CxA.
 7. Perform commissioning PFPT & FPT at the direction of the CxA.
 8. Complete commissioning process PFPT & FPT procedures.
 9. Provide information requested by the CxA for final commissioning documentation.
 10. Correct deficiencies found in the CxA's reports.

1.10 CxA'S RESPONSIBILITIES

- A. CxA Services Performed In The Construction Verification Phase:
 1. Develop Commissioning Plan:
 - a. Draft PFPT system readiness checklists.
 - b. Draft FPT narratives.
 - c. Draft Commissioning Process Schedule.
 - d. Draft list of system trends to be completed 1-week before FPT system demonstration.
 2. Facilitate a kick off meeting with owner (reps), design team & contractor to discuss commissioning process & plan. Deliver meeting minutes to attendees.
 3. Coordinate and direct commissioning activities using consistent protocols and forms, regular communications, consultations with all necessary parties and schedule updates.

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4. Review all architectural, design, & contractor submittals applicable to systems and equipment being commissioned in the sampling rate table, in conjunction with the design team.
5. Review the following Testing, Adjusting, and Balancing for HVAC submittals in conjunction with the design team:
 - a. Qualification Data.
 - b. Contract Documents Examination Report.
 - c. Strategies and Procedures Plan.
 - d. Sample Report Forms.
 - e. Instrument Calibration Reports.
6. Review RFI's, Addendums, Bulletins, and Change Order Proposals.
7. CxA shall provide field reports on a weekly basis. Reports shall be submitted to the Commissioning Team each week during the construction verification phase.
8. Develop & update construction checklist and issues/corrective action logs throughout project.
9. Review contractors PFPT updates.
 - a. CxA will execute a min of 20% random check of the checklists and sign off accordingly.
10. Deliver FPT's for contractor use in completing system FPT dry-run.
11. Review and update FPT's based on contractor feedback.
12. CxA shall review contractor/manufacture supplied equipment start-up forms.

B. CxA Services Performed In The Acceptance Phase

1. Facilitate weekly Commissioning Team meetings throughout performance testing. Deliver meeting minutes to attendees.
2. Verify testing, adjusting, and balancing of Work are complete.
3. Perform final testing and verification of test and balance report as identified in PART-3.
4. Execute Functional Performance Testing at **SAMPLING RATES** indicated below:

SAMPLING RATE TABLE (for Observations & Testing)	
EQUIPMENT SYSTEMS	SAMPLING RATE
Building ENVELOPE SYSTEMS	
Air Intrusion Envelope	100% of New Construction
HVAC SYSTEMS	
Hydronic Piping Systems	50%
Duct Accessories	100%
HVAC Power Ventilators	100%
Air Terminal Units	100%
Hydronic Boilers	100%
Gas-Fired Radiant Heaters	100%
Air-to-Air Energy Recovery Equipment	100%
Water-to-Air Heat Pumps	100%
Unit Heaters	100%

5. Facilitate FPT demonstration with Owner (Reps) & Contractors.
 - a. Collect BAS Printouts during FPT demonstration
 - b. Collect BAS Trending printouts
6. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues/Corrective Action Log.
7. Update Issues/Corrective Action Log
8. Commissioning Agents shall provide Field Reports on a WEEKLY basis. Reports shall be submitted to the CxA Team EACH week during the Acceptance Phase.

C. CxA Services Performed In The Occupancy, Operation, Warranty Phase

1. Facilitate seasonal deferred FPT demonstration.
2. Update Issues/Corrective Action Log.
3. Project Closeout and deliver Final CxA Report to the Owner (Includes Paper & Digital Copy of Final Report). Report shall include:
 - a. Commissioning Activities Executive Summary

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- b. Prefunctional Checklists
- c. Field Observation / Inspection Reports
- d. Executed Functional Performance Tests
- e. BAS Trend Logs
- f. Air Intrusion Envelope Testing
- g. TAB Sampling Results Report
- h. Updated Issues/Corrective Action Log
- i. Project Record Documents Comments
- j. O&M Manuals Comments

1.11 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of Heating, Ventilation, and Air Conditioning submittals, systems manuals, and other documents and reports.
 - 2. Plan for delivery and review of HVAC&R instrumentation and control submittals, systems manuals, and other documents and reports.
 - 3. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 4. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
 - 5. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
 - 6. Certificate of readiness certifying that HVAC&R systems, subsystems, and equipment, are ready for testing.
 - 7. Certificate of readiness certifying that HVAC&R instrumentation and control systems, subsystems, and equipment, are ready for testing.
 - 8. Test and inspection reports and certificates.
 - 9. Corrective action documents.
 - 10. Verification of testing, adjusting, and balancing reports.

1.12 RECOMMISSIONING

- A. Should re-commissioning of any tests indicated in PART 3 of this specification be required, the owner shall request the services for additional commissioning with a RFP (Request For Proposal), and deduct the cost of the services from the contractor's final payment.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

- A. CxA to receive certified submittals from contractor that that building enclosure is complete, including but not limited to, all structural components, the air barrier and vapor barrier complete, windows and doors installed, door hardware complete, door sweeps and weather stripping complete, floor and ceilings complete.
- B. CxA to receive certified submittals from contractor that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- C. CxA to receive certified submittals from contractor that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- D. CxA to receive certified submittals from contractor that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

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- E. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- F. Inspect and verify the position of each device and interlock identified on checklists.
- G. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- H. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.2 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning tests at the direction of the CxA.
- B. Provide all project preparation and setup tests as directed by the CxA, this may include but is not limited to temporary sealing of intentional openings, removing ceiling tile, opening access doors, opening interior doors and affixing them so they cannot close during the tests. This may include preparation of adjoining spaces. This would also include staging the building so no people will be opening doors or windows during the tests.
- C. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- D. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- E. The CxA along with the HVAC&R contractor, testing and balancing Contractor, HVAC&R Instrumentation and Control Contractor, Plumbing contractor, and Electrical contractor shall prepare detailed testing plans, procedures, and checklists for all systems, subsystems, and equipment.
- F. Tests will be performed using design conditions whenever possible.
- G. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- H. The CxA may direct that set points be altered when simulating conditions is not practical.
- I. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- J. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, Plumbing system, or Electrical system, document the deficiency and report it to the Design Team and Owner in writing. After deficiencies are resolved, reschedule tests.
- K. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.3 BUILDING ENVELOPE SYSTEMS TESTING PROCEDURES

- A. Air Intrusion Envelope Testing: Conduct an air intrusion envelope test according the procedures listed below and update the issues/corrective action log. Ensure that the building enclosure and components are complete and operational such that the performance of the building envelope tests would not be adversely affected. Should the test results indicate airflows greater than 0.25 CFM75/Sq.Ft., the test report shall be marked as FAILED and owner will contract the services for Re-commissioning and deduct the cost of the service from the contractor's final payment.

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1. Air Intrusion Envelope Testing Preparation:
 - a. Adjust all building components in accordance with the table listed below. Close all operable openings and seal other intentional openings to evaluate envelope air tightness.

Pre-Test Building Preparations Table	
Building Component	Envelope Conditions
Exhaust Fans w/Dampers	Sealed
Exhaust Fans wo/Dampers	Sealed
Supply Fans w/Dampers	Sealed
Combustion Air Intake Louvers	Closed
Air Handling Equipment Outdoor Air Intake Openings.	Sealed
All HVAC equipment, boilers, hot water heaters, clothes dryers, and equipment requiring combustion air (including kitchen equipment, etc.).	Off
PTAC Units & Unit Ventilators	Sealed
Windows	Closed and Latched
Exterior Doors	Closed and Latched
Opening leading to outside the test zone.	Closed
All HVAC ducts going from inside the test zone to outside the test zone.	Sealed
All electrical conduits going from inside the test zone to outside the test zone.	Sealed
Openings within the test zone.	Open
Floor drains and plumbing traps.	Filled
Elevator pressure relief openings.	Closed
Elevator Doors	Closed
Elevator door frame spacing between the elevator door and frame.	Open
Rooms with Exterior, non-ducted louvers.	Room Door Closed
Loading Dock Doors	Room Door Closed

- b. Establish the interior test zone. This is accomplished by opening all interior building doors including fire doors, corridor doors, pass-throughs, in the test zone so that a uniform inside pressure is created within the zone. If there are hard ceilings with access doors, all access doors are to be open.
- c. Measure and record the wind velocity and direction on the windward side of the building at a distance of 30 to 50 feet away from the building. Preferred test conditions are wind velocity of 0 to 4 mph. If the surrounding building induced winds or the wind is gusting more than 4 mph above the steady state wind then the test should not be performed due to accuracy limits.
- d. Measure and record the outside temperature. Preferred test conditions are outside temperatures from 35 Deg.F. to 95 Deg.F. If test is performed below 35 Deg.F. there is a possibility of freezing pipes. If the test is performed above 95 Deg.F. damaging finished materials, building finishes or worker safety becomes a concern.
- e. Measure and record the indoor and outdoor temperatures at the beginning of the test so that their average values can be calculated.
- f. Determine the height & temperature factor. The factor is the product of the absolute value of the indoor/outdoor air temperature difference multiplied by the building height. If the factor is less than 1,180 ft.Deg.F., perform the test. If the factor is greater than 1,180 ft.Deg.F., the stack effect may influence the building envelope pressure difference and will reduce the accuracy of the result. When the factor is greater than the above stated values, the entire test shall be performed both under a pressurization and depressurization modes utilizing ASTM E 1827 Blower Door Test Method and the minimum induced test pressure shall be 25 Pa (0.10 in.w.c.).
- g. Open all doors, windows, and other openings that connect portions of the building outside the test zone envelope with the outdoors. For example, if the building is a combination of office and warehouse, and only the office portion of the building is to be tested then open the warehouse doors. If the entire office and warehouse is to be tested, then all office and

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- warehouse doors are to be closed to the outside but the doors between the office and warehouse are to be open.
- h. Remove sufficient ceiling tiles for lay-in ceilings, or open sufficient access panels for hard ceilings, where the pressure between the ceiling cavity and the room is equalized with +/- 10% of the building envelope test pressure.
 - i. Record the condition of the buildings components including windows, exterior doors, interior door, stairwell doors, elevators doors, walls, access doors, roof and floor (i.e. sealed or unsealed, open or closed, etc.).
2. Blower Door Test Method Procedures:
- a. Install the blower door in an entry, window or vent opening. The openings must be sealed or taped to avoid leakage at these points. Orient the blower door appropriately for depressurization or pressurization as required. The installation should have minimal obstructions of airflow into and out of the building.
 - b. Install the pressure measuring instrument across the building envelope. It is good practice to use more than one location across the building envelope for pressure measurements. Preferred locations for exterior pressure measurement locations should be those that avoid extremes of exterior pressures. A good location avoids exterior corners and complex architectural features and should be close to the middle of the exterior wall.
 - c. In addition, buildings more than 4 floors or 48.0 ft in height shall have pressures measures at a minimum of 2 locations or every 4 floors, whichever is greater.
 - d. Average 10 baseline pressure points of 10 seconds per point, where the variation between any point and the mean must be not greater than 1 Pascal.
 - e. Zero the pressure sensor by connecting the differential ports together. Some blower doors may perform this or an equivalent step automatically. Follow the manufacturer's instructions accordingly.
 - f. Before beginning test, measure and record the baseline building differential pressure across the airflow measurements device with the blower off. If a damper is used to control airflow, it should be in a fully closed position for the baseline building pressure measurements. If the air moving equipment employs a blank-off plate, it should be fully closed for the baseline building tests.
 - g. Start the blower door fans and pressurize / depressurize the building to the highest specified induced pressure differential. Measure and record the building envelope difference pressure.
 - h. Pressure readings are to be taken to produce an accurate average building pressure. Fluctuations in pressure due to wind require pressure measurements to be taken on both the windward and leeward side of the building and averaged. If the buildings height or building configuration causes internal building pressure fluctuations then interior pressure shall be taken and averaged.
 - i. Perform a minimum of 10 building envelope pressure differentials and their corresponding airflow measurements for both the pressurization mode and the depressurization mode (a total of 20 measurements). The measurements shall be taken over a minimum of 10 seconds. The range of the building envelope pressure differences should be from a minimum of 25 Pa (0.10 in. w.c.) to maximum of 75 Pa (0.30 in w.c.). Use increments of 5 Pa (0.02 in w.c.) for the full range of building envelope pressure differences. (i.e. 25, 35, 40, 45, 50, 55, 60, 65, 80, 75 Pa, or 0.10, 0.14, 0.16, 0.18, 0.20, 0.22, 0.24, 0.26, 0.28, and 0.30 in. w.c.)
 - j. Conduct test at each building envelop pressure differential. Allow the fan and instrumentation to stabilize prior to taking any measurements. At each pressure differential, measure the airflow rate and the pressure differences across the envelope over at least a 10 second time interval. For each building envelope pressure differential test, collect data for both pressurization and depressurization.
 - k. After conducting the pressure test, measure and record the baseline building differential pressure across the airflow measurement device with the fan off and sealed.
 - l. Report the building envelope pressure differential, and the airflow for each test and the beginning and ending baseline building differential pressure.
 - m. Subtract the average baseline differential pressure from the building envelop differential pressure and report this value for both pressurization and depressurization. Some equipment may perform this step, or an equivalent step, automatically follow the manufacturer's instructions accordingly.
 - n. Measure and record the indoor and outdoor temperature at the end of the test so that their average values can be calculated.
3. Data Analysis and Calculations:

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- a. If the airflow measuring instrumentation being utilized does not provide the volumetric airflow at the temperature and pressure of the air flowing through the flowmeter during the test, the airflow values must be corrected for density.
 - b. When correcting the readings of the airflow measurements for density, the preferred method is to use the temperature and the actual barometric pressure. A method to correct for density using temperature and elevation is available, but does not account for weather impact. In the pressurization mode this will be the outside air temperature and barometric pressure. For depressurization test this will be the inside air temperature and barometric pressure.
 - c. Average the baseline building envelope pressures measured before and after the flow measurements. Subtract the average from the measured envelope differential pressures readings to determine the corrected induced envelope pressures.
 - d. Plot the measured airflow against the corrected induced pressure differences on a log-log plot to complete the air leakage graph for both pressurization and de-pressurization (for an example, see Appendix C, Section C.10 of the current edition of the NEBB Procedural Building Envelope Testing).
 - e. Use the data to determine the air leakage coefficient.
 - f. Correct the air leakage coefficient (C) to standard conditions. Use the data to determine the pressure exponent separately for pressurization and depressurization.
 - g. If the pressure exponent (n) is less than 0.45 or greater than 0.8, then the test is invalid and shall be repeated.
 - h. Use a log-linearized linear regression technique and the associated equation in Appendix C, Section C.5.5. of the current edition of the NEBB Procedural Building Envelope Testing, where Q is the airflow rate, in CFM, and ΔP is the differential pressure in Pa (in.w.c.). In determining the fit of the above equation, the confidence intervals of the derived air leakage coefficient (C) and pressure exponent (n) should be calculated.
 - i. The effective leakage area, A_L , can be calculated from the corrected air leakage coefficient and the pressure exponent using a reference pressure (ΔP_r). Calculate the leakage areas separately for pressurization and depressurization.
 - j. To obtain a single value for flow coefficient, pressure exponent and leakage area for use in the other calculations, the average of these values from the pressurization and depressurization envelope flows and pressure differences, with their offsets removed, may be combined together. This combined data set then is used in the same way as each individual data set to obtain C, n, and A_L for the combined data. If the flow at a specified pressure difference, such as 50 Pa, is desired, it should be determined using the derived C and n and the specified reference pressure.
 - k. Determine the upper confidence limits for the derived values which shall not exceed the leakage rate per square footage of air barrier.
4. Air Intrusion Envelope Test Report Data:
- a. Required Data: Building description including location, address, (street, city, state or province, zip or postal code, country, building orientation (N,E,S,W, etc.) and elevation above mean sea level in ft. (m).
 - 1) Technician Name
 - 2) Date/Time of the inspection test.
 - 3) Construction data including:
 - a) Date built (estimate if unknown).
 - b) Floor areas for conditioned space, attic, basement, and crawl space.
 - c) Wall areas.
 - d) Roof area.
 - e) Building air barrier height.
 - f) Type of floor (slab on grade, crawl space, etc.).
 - g) Surface area of building enclosure.
 - 4) Condition of openings in building enclosure listed in Pre-Test Building Preparations Table.
 - 5) Procedure used.
 - 6) Measurement Data of all Recorded Information required in test.
 - 7) Calculated Data including:
 - a) Building Temperature-Height Factor.
 - b) Air Density both inside and outside.
 - c) Corrected values of airflow, pressure, density, airflow leakage rate.
 - d) Error calculations for measured and derived values, including the values for precision index, bias, and overall uncertainty.

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- e) Equivalent leak opening at test pressure and at standard operating pressure.
- f) Log graph of acceptable leakage rates and actual leakage rates.
- g) Pass or Fail.
- 8) Deviations from standard procedures.

3.4 TESTING AND BALANCING VERIFICATION PROCEDURES

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Provide technicians, instrumentation, tools, and equipment to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing contractor 10 days in advance of the date of final inspection. Notice will not include data points to be verified.
 - 2. The testing and balancing contractor's test and balance engineer shall conduct the final inspection in the presence of the Commissioning Team.
 - 3. The testing and balancing contractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 4. The Design Team and CxA shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - a. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed in section "230593-Testing, Adjusting, and Balancing for HVAC", the measurements shall be noted as "FAILED.". If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
 - b. Testing and balancing contractor shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report and request a second final inspection.
 - c. The Design Team and CxA shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - d. If the second final inspection also fails, owner will contract the service of another TAB contractor to complete the TAB work according to the Contract Documents and deduct the cost of the service from the contractor's final payment. The owner will also contract the services for Re-commissioning and deduct the cost of the service from the contractor's final payment.

3.5 INSTRUMENTATION AND CONTROL FOR HVAC TESTING PROCEDURES

- A. Provide technicians, instrumentation, tools, and equipment to test performance of instrumentation and control for HVAC systems, at the direction of the CxA.
 - 1. Provide CxA with log documenting completion of startup tests.
 - 2. The CxA will notify the Instrumentation and Control Contractor 10 days in advance of the date of final inspection.
 - 3. The Instrumentation and Control Contractor's engineer shall conduct the final inspection in the presence of the Commissioning Team.
 - 4. The Design Team and CxA shall randomly select control sequences to be demonstrated. Demonstrate actual field operation of each sequence of operation as specified in section "230993-Sequence of Operation for HVAC Controls." Demonstration shall be limited to the extent that can be accomplished in a normal 8-hour business day.
 - a. If a control sequence fails during final inspection and cannot be easily remedied during the final inspection, the control sequence shall be noted as "FAILED." If the number of "FAILED" control sequences is greater than 10 percent of the total number of control sequences tested during the final inspection, the startup test report shall be considered incomplete and rejected.
 - b. Instrumentation and Control Contractor shall re-verify startup test reports and make adjustments. Revise the final test report to include all changes and resubmit the final test report and request a second final inspection.

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- c. The Design Team and CxA shall randomly select control sequences to be demonstrated. Demonstrate actual field operation of each sequence of operation as specified in section "230993-Sequence of Operation for HVAC Controls." Demonstration shall be limited to the extent that can be accomplished in a normal 8-hour business day.
- d. If the second final inspection also fails, owner will contract the services for Re-commissioning and deduct the cost of the service from the contractor's final payment.
5. Demonstrate accuracy of control devices to CxA as specified in section "230900-Instrumentation and Control for HVAC." Demonstration shall be limited to the extent that can be accomplished in a normal 8-hour business day. CxA to update the issues/corrective action log with results.
6. Provide CxA with graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. CxA will require further tuning of each loop that displays unreasonably under-or over-damped controls and update the issues/corrective action log.
7. If the CxA determines that equipment and systems operate satisfactorily at the end of the final start-up, testing, and commissioning phase, CxA will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification.

3.6 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Provide technicians, instrumentation, tools, and equipment to verify HVAC&R systems, subsystems, and equipment testing at the direction of the CxA.
- B. Hydronic Systems Testing and Acceptance Procedures: Testing requirements are specified in hydronic system specification sections. Provide submittals and test data to the CxA.
- C. Duct Accessory Testing and Acceptance Procedures: Testing requirements are specified in duct accessory specification sections. Provide submittals and test data to the CxA.
- D. HVAC Power Ventilator Testing and Acceptance Procedures: Testing requirements are specified in HVAC power ventilator specification sections. Provide submittals and test data to the CxA.
- E. Air Terminal Unit Testing and Acceptance Procedures: Testing requirements are specified in air terminal unit specification sections. Provide submittals and test data to the CxA.
- F. Hydronic Boiler Testing and Acceptance Procedures: Testing requirements are specified in hydronic boiler specification sections. Provide submittals, test data, inspector record, and boiler certification to the CxA.
- G. Gas-Fired Radiant Heater Testing and Acceptance Procedures: Testing requirements are specified in gas-fired radiant heater specification sections. Provide submittals and test data to the CxA.
- H. Air-to-Air Energy Recovery Equipment Testing and Acceptance Procedures: Testing requirements are specified in air-to-air energy recovery equipment specification sections. Provide submittals and test data to the CxA.
- I. Water-to-Air Heat Pump Testing and Acceptance Procedures: Testing requirements are specified in water-to-air heat pump specification sections. Provide submittals and test data to the CxA.
- J. Unit Heater Testing and Acceptance Procedures: Testing requirements are specified in unit heater specification sections. Provide submittals and test data to the CxA.

END OF SECTION 019113