

Commissioning Built-Up Air Handlers

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AIA Quality Assurance



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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

For larger projects, the choice of air handlers has been built-up units. Built-Up Units are specifically manufactured and assembled to provide the required performance using the site utilities, new or existing. Each unit will have components and sections specific to the project requirements. These units will require automation that allow for control, alarming and trending.

The commissioning of these units will require a very “hands on” approach, and a detailed understand of the controls, hardware and software. The commissioning provider can take a leading role to assure the equipment and controls are installed and will perform per the Owner’s requirements and the final approved submittals.

Learning Objectives

1. Describe what a built-up unit is and what components may be part of the unit.
2. Review the role of commissioning during design and construction.
3. Outline the steps for (pre-functional) installation commissioning.
4. List the steps for (functional) operational commissioning.

What is a Built-up Air Handler?

- A unit that is not “off the shelf” but is built specifically for the requirements outlined in the OPR, BoD and design documents.
- A unit that may include components from various manufactures but assembled by one manufacture.
- The unit may have dampers, chilled water coils, steam coils, hot water coils, fans, filters, wheels, humidifiers, dehumidifiers, and other components to meet the design requirements.
- A unit that normally uses site utilities like chilled water, hot water, steam, and electrical service.
- A unit that should allow for access to all components within the unit.

What is a Built-up Air Handler?



AHU Commissioning at the OPR and BoD Level

The Commissioning provider should review the OPR and BoD.

- Does include Cx Services and Support Requirements?
- Does it include details on the AHU, BAS, Utilities?
- Does it address GUIDELINE 36-2021 -- High-Performance sequences of operation for HVAC systems?
- Does it include capacities, setpoints, ranges, accuracy, values.
- Does it include requirements for trends and alarms?
- Does it include BAS requirements for change of state (range) and change of value (range) for trends?

AHU Commissioning at the SD Level

Cx - SD design review

- Not looking for details. More of a project understanding. General Review.
- Does it start to address OPR, follows the BoD (not looking for details)
- Does it include or identify Cx Specifications.
- Start of schedule and details.

AHU Commissioning at the DD Level

Cx - DD design review

- Address Cx comments from SD.
- Equipment Schedules (should be mostly completed and include performance requirements)
- AHU, Cx and BAS Specs (do they match the drawings/schedules)
- Access, clearances, pulls, replacement. (Hatched on plans)
- More details (BAS architecture)
- Assure BAS support for commissioning is in the contract documents.
- Assure Factory Start-Up is in the contract documents.
- Schedule completed or near completed.

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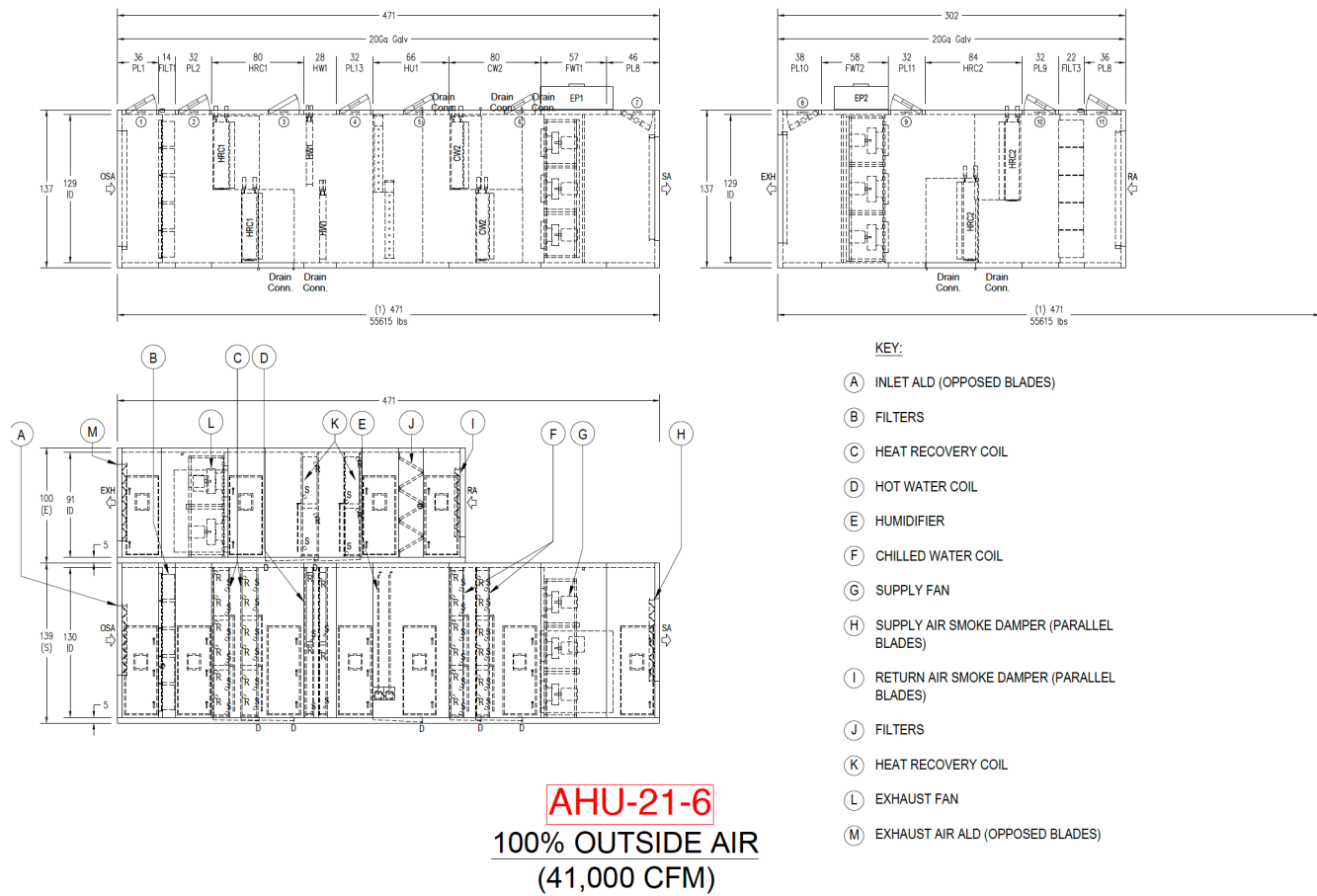
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AHU Commissioning at the CD Level

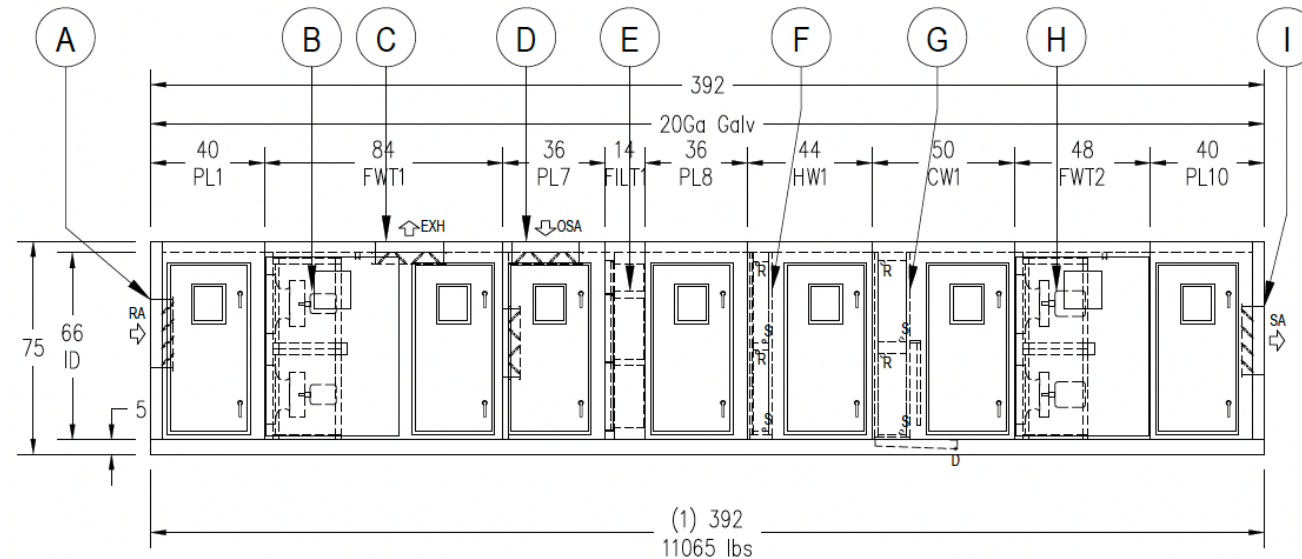
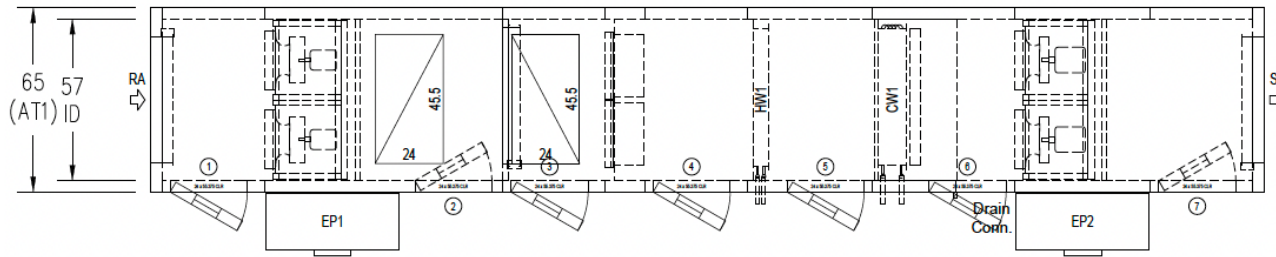
Cx - CD design review

- Address Cx comments from SD.
- The drawings and specifications are 100%.
- All schedules and details are complete and align with the specifications.
- SOO finished with all required details (functions, setpoints, alarms, trends, etc.)
- Schedule with Cx Activities completed.
- Draft BAS Screens.
- If additional comments are made, hold a meeting with the project team.

AHU Commissioning at the CD Level



AHU Commissioning at the CD Level



KEY:

- (A) INLET ALD (OPPOSED BLADES)
- (B) RETURN FAN
- (C) EXHAUST ALD
- (D) OUTDOOR AIR ALD
- (E) FILTERS
- (F) HOT WATER COIL
- (G) CHILLED WATER COIL
- (H) SUPPLY FAN
- (I) SUPPLY AIR ALD (OPPOSED BLADES)

AHU Commissioning CD – Post CD

Meet with Owner, CM, A/E. Cx Scope

- Review the BOD and Specs.
- SOO review with A/E (ASHRAE Guideline 36?)
- Meet with BAS vendor (spec review, trend, alarms, graphics)
- Schedule Review.
- SOO review with BAS vendor. Assure it match the A/E SOO.
- A/E spec (copy paste) Not always a bad thing.
- Confirm Downstream tie-in. (all utilities will be available?)

Cx Submittal Review and Comment

- Submittal provides the required information to review.
- Submittal is “Approved”. Approved as noted leads to issues. Record submittals are best
- Not just an equipment cut.
- AHU (Casing, doors, windows, support, opening, damper, actuators, coils, fans, floors, drains, filter racks, filters, ETC)
- Utilities (CW, HW, Steam, Humidifier)
- BAS Panels, Devices, Distribution

Cx Submittal Review and Comment

Ask for a “Record Submittal”

4. Walkways and ladders are to be provided for AHUs to access upper tiers.
5. Furnish and install in accordance with manufacturer's guidelines and recommendations and in full compliance with mechanical plans and specifications.
6. The AHUs shall be mounted on a concrete pad with vibration isolation in addition to internal springs.
7. Contractor shall coordinate coil pull access and all AHU access requirements with all new and existing equipment. All access requirements for existing equipment shall be maintained.
8. All supply fans shall be provided with isolation dampers for each fan with the exception of fan array.
9. Steam humidifier coils within AHU's shall be mounted 2'-6" (minimum height) from finished floor to bottom of first coil. The contractor shall coordinate steam coil outlet elevations to ensure all condensate is pitched via gravity to the inlet of each condensate pump.
10. The contractor shall coordinate the location and size of pads with structural contractor and approved AHU submittals.
11. The supply fans shall be provided with vibration isolation per the specifications.
12. The contractor shall coordinate all controls requirements with the controls contractor. Coordinate all AHU casing penetrations required for control wiring prior to AHU fabrication to minimize field penetrations.
13. The contractor shall coordinate reconnection of power and control wiring between unit splits.
14. The unit shall be provided with dampers on the outside air intake, return air, spill air and supply discharge. Fan discharge damper shall be a smoke damper where indicated.
15. All dampers shall be mounted such that the actuators are located on the sides (not top or bottom).
16. All AHU's shall be provided with removable access panels at all fan sections.
17. Contractor to coordinate condensate trap depths and locations with the AHU manufacturer prior to shipment of AHUs.
18. Manufacturer to confirm there is an even air distribution in the OA section of the units. Manufacturer shall confirm there will be no nuisance freeze stat alarms from 25% to 100% of the design airflow.
19. Coordinate final MOP sizes with Electrical Contractor.
20. Coordinate installation of all relays, modules, DSDs, etc. with Fire Alarm Contractor.
- 21. Opposed blade dampers to be provided in all noted cases.**
- 22. Fan selections noted within the submittal to be reselected for more optimal fan curves.**
- 23. AHU naming to be corrected for all future correspondence. Full AHU submittal to be resubmitted for record with correct AHU names noted.**
- 24. Final filter (12") to be provided as noted.**
- 25. AHU-21-5 return section has not been submitted. Section to be submitted under a separate cover for review.**
26. See following pages for additional comments.

CX Factory Acceptance Testing

AHU FAT

- CFM, static pressure, leakage, deflection, sound, vibration.
- Recommended for both business and Operational Needs.
- Do as much as possible.

BAS FAT

- Software Tests.
- Bench test as much as possible.
- Review installed code.
- Confirm setpoints (trends and alarms maybe).

CX Factory Acceptance Testing

1.6 FACTORY TESTING

- A. A factory performance test shall be performed for the following air handlers: AHU-1, AHU-2, AHU-3 and AHU-4. The performance tests for the air handling units require that the air handling units are complete with fan, fan unit casing, and discharge plenum coils and filters. As specified hereinbefore, factory tests required for specified AHU's shall be witnessed by designated representatives of the Engineer and Owner (total six [6] people). The unit manufacturer shall notify the Construction Manager at least four (4) weeks prior to any scheduled testing and shall have a formal written procedure prepared and submitted to the Engineer. The unit manufacturer shall pay for all air and ground transportation, lodging and meals for the designated witnesses to attend the testing. If multiple trips are required, they shall be paid for by the unit manufacturer. The performance tests for the air conditioning units shall be in multiple stages.
- B. A document detailing the performance test installation and method of testing air handling units shall be submitted to the Owner for review before the testing program is executed. The document shall address the following:
 - 1. Location where tests shall be performed.
 - 2. That the installation of the air handling units shall be tested in accordance with Installation B - free inlet, ducted outlet as described in AMCA Standard 300.
 - 3. All relevant manufacturer's performance data (e.g., fan curves, coil performance and column for entering test results).
 - 4. Outline of proposed report format. This outline shall detail performance assessments that shall be made and how they shall be determined.

CX Factory Acceptance Testing

- a. Testing of Part Assemblies Prior to Approval of Pre-Production Units
 - 1) Fan: Fan manufacturer's standard certification, including vibration data at multiple load points of 25%, 50%, 75% and 100% of rated capacity.
 - 2) Coils: Coil manufacturer's standard tests and certification of coil design.
 - 3) Electric Wiring: Electrical supplier's standard certification.
 - 4) Variable Speed Motor Controller: Electrical and mechanical parameters of the drive system, including the combined efficiency of the controller and motor combination for each fan drive.
 - 5) Full details of all test equipment and instruments, including test equipment calibration certificates.
 - 6) Comprehensive procedures for all tests and commissioning activities.
 - 7) Electrical and mechanical parameters of the drive system, including the combined efficiencies of the controller and motor combination for each fan drive.
- C. The air handling unit manufacturer shall conduct testing in accordance with the ARI 350 standard to demonstrate the acoustical performance of the air handling unit. The manufacturer shall report guaranteed maximum octave-band sound power levels in dB re: 10⁻¹² watts for, at a minimum, the casing radiated, unit intake and unit discharge. The acoustical measurements shall be made with the unit operating at 100%, 75%, 50% and 30% of design airflow capacity.
- D. The cabinet shall be tested at 1.25 times the unit's design operating static pressures for both the high- and low-pressure sides. Cabinet leakage shall not exceed a Leakage Class rating of 9 as defined by ANSI/ASHRAE Standard 111. Total leakage shall not exceed 1% of the unit capacity. Airflow measurements shall be performed in compliance with AMCA Standard 210 Annex B.
- E. Fan Vibration Testing: Fan wheel and shaft assemblies shall be dynamically analyzed after the fan, motor and drive assemblies have been installed in the unit. The fan shall be analyzed with an electronic balance analyzer with a tunable filter. Vibration measurements shall be taken on each bearing housing in the horizontal, vertical and axial positions with the filter tuned to the fan rpm.
- F. Acoustical Testing: In addition to the sound power level data included in the submittals, the manufacturer shall perform a sound test for each representative testable size unit. Testable size units shall be defined as units of less than 80,000 cfm (37.7 cu.m/s) that are less than 16 ft. (4.88m) wide and less than 65 ft. (19.8) long. The tests shall verify for each size unit that the inlet and outlet sound power levels do not exceed the specified levels - in the first five (5) octave bands 63 through 8,000 - by more than is allowable by AMCA 311.

G. Air Handling Unit Performance: Each factory-tested unit shall be tested to confirm the scheduled airflow and total static pressure for the supply and return air sections of the unit. Airflow (cfm) readings shall meet or exceed the specified airflow, and the total static pressure (inches) of the fan section shall meet or exceed the specified static pressure as indicated in the schedules

H. At the conclusion of the tests, a detailed certified report, including all data and test methods, shall be presented to the Owner or his representative(s) for approval.

Receipt Verification

Completed by the CM and Subs (Prove the provided equipment, systems, device match the approved submittals with all accessories provided.)

Confirms all AHU components (Internal and external) (Right, clean, free of damage)

- Dampers and Actuators.
- Filter Racks (Boxed Filters)
- Coils.
- Fans.
- VFD.
- Wheels.
- Casing and seals

Receipt Verification

Completed by the CM and Subs

- Humidifiers.
- Dehumidifiers.
- Lights and Receptacles.
- Door, window, locks.
- Utility Connections.
- Sensors (Factory Mounted)

Cx - Installation Checks (Pre-functional)

Confirms all AHU components, Back checks the receipt verification. Generate installation checks for execution.

- Access and clearances.
- Flooring and walls (Damage, Defects)
- Installation height (Pad, base, drainage outlets) Enough for Traps.
- Dampers and Actuators (Blades, seals, connections)
- Filter Racks (sealed) Note: Boxed Filters.
- Coils (Sealed, No major damage) Note: bent fins.
- Fans (Size, Type, Damper, Vibration Isolation (Shipping/Blocking)
- Motors (HP, Type, Insulation Rating)

Cx - Installation Checks (Pre-functional)

- Wheels (Correct installation, Damage, Controllers)
- Humidifiers (Correct installation, Damage)
- Dehumidifiers (Correct installation, Damage)
- Lights (In place with switching)
- Door, locks, Seal (Open, close, lock) Windows provided?
- Utility Connections (Location, size, connection type) Note: No gaps thru unit.
- Sensors (Type, Location, Wiring) Air Monitors, Freeze stats.

Cx - Installation Checks (Pre-functional)



Cx - Installation Checks (Pre-functional)

- VFDs (Correct Type, HP, Voltage, Amp Rating)
- Disconnects at Fans/Motors.
- Electrical Feeds and Breaker Size, Type.
- Emergency Power Feed (If required)
- 3rd Party Controls (Energy Recovery, Desiccant Wheel)
- Gas, Chilled Water, Hot Water, Steam and Condensate Piping.
- Strainers, Balancing Valves.
- Cooling Coil Drain Trap.
- Steam Traps.
- Condensate Coolers.

Cx - Installation Checks (Pre-functional)



Cx - Installation Checks (Pre-functional)

- BAS Sensor Installation, Type and Location.
- BAS Controller Type.
- BAS Panel Location (Power vs Controller) (Line Voltage vs Low Voltage)
- Sensor Calibration.

Cx - Installation Checks (Pre-functional)



Cx - Installation Checks (Pre-functional)

- Pipe Route and Hangers. (Does not block access, Not over electrical)
- Valves Isolation, Balancing Valves, Control Valves. (Handles)
- Gauges and Thermometers.
- Strainers and Drain Valve
- Drains and Vents. (Coils and Piping)
- Insulation. (Duct and Piping to Unit)
- Duct Connections at Unit.
- Duct mounted Electric Coils, controlled by AHU/BAS.

Cx - Installation Checks (Pre-functional)



Cx - Installation Checks (Pre-functional)



Installation Issues

- **Anything is possible. Things never seem to be finished, correct.**
- Not enough height to allow for cooling coil condensate trap installation.
- Missing intermediate drains in stacked coils.
- Missing BDD for fan walls.
- Incorrect filter type or rating (MERV Rating, HEPA gasket seal vs knife edge)
- Missing test ports.
- Missing, broken door seal and latches.
- Air leakage at section connection(s) (water in unit)
- Missing blank/safe off metal at coils.
- Humidifier installed too low in unit.
- Incorrect tagging of utility connections (Like CW S vs R)
- Vibration isolation missing or not freed.

Installation Issues

- Missing sensors, thermostats, gauges (Unit or Utilities)
- Incorrect type or location/installation of sensors. (point vs full coverage)
- Dampers won't open, close or seal tight. (linkage)
- Missing drains and vents at coils.
- Missing Circuit balancing valves. (multiple coils)
- Missing strainers.
- Missing Pete's Plugs.
- Belt tension/alignment incorrect. (really found at startup)
- Incorrect motor HP, type, or insulation rating.
- Dirt in unit.
- **Details Matter (Design and Vendor Details)**

Installation Issues – Documentation and Correction

- Note all issues.
- Keep the issues log up to date.
- Be ready to provide input on the problem and how its should be resolved to meet the Cx requirements.
- If it is an AHU issue, meet with the vendor, CM and/or owner. Identify a path forward, schedule and note the impact on commissioning.
- If it is a utility issue, meet with the Subcontractor and CM. Identify a path forward, schedule and note the impact on commissioning.
- If it is a BAS issue, meet with the BAS vendor and CM. Identify a path forward, schedule and note the impact on commissioning.
- If a general construction issue, meet CM. They will need to identify a path forward, schedule and document the impact on commissioning.

Start-up (SAT)

- Completed by Vendor and Subcontractors. CM should coordinate the required contractors to support startup.
- Review the startup plan and documents before starting.
- Assure a safety plan is in place. Remove lockouts per the plan.
- Energize utilities first. Open valves, provide power, assure the system are operational.
- Note that gas pressure must be set.
- Allow the Vendor to run thru startup. Cx should witness the start-up. May be used to complete some functional tests.
- All sections of the startup plan should be executed.
- Start-up Documents should be fully executed. (No Blanks)
- Deficiencies must be addressed.
- Redo Startup steps if required.

Test and Balancing (TAB)

- TAB contractor should complete TAB before functional testing.
- Issues must be corrected.
- Hand-written report is OK, as long as there are no issues.
- All CFM and GPM readings should be within 10% (5% if in spec).
- Temperature checks by TAB should be completed.
- TAB and BAS required for calibration. Air Flow monitors for example.
- TAB and VFD vendor must confirm Fan/Motor/VFD operation.
- Final Report may follow later.

Cx Operational Tests (Functional)

- Use only the final approved Vendor and BAS submittals to generate the test plan.
- Review the test plans with the site BAS contractor. (Field Tech)
- Use setpoint changes as much as possible.
- Use point overrides only when needed.
- Use signal generator if required.
- Confirm there is a way to test the AHU. Are all floor level dampers open? Are the VAV boxes open or under control? Do you need a way to discharge air to the outside?

Cx Operational Tests (Functional)

- Confirm the power and utilities are on. (sometimes off after TAB)
- Test operation of all lights and switches.
- Test operation of all receptacles.
- Verify operation and all gauges and thermometers.
- Verify operation of the UV lights.
- Verify all dampers are in their normal positions based on the SOO.
- Verify all valves are in their normal positions based on the SOO.
- Verify all filters are in place and clean. (Should not be construction filters)

Cx Operational Tests (Air Flow)

- Start with airflow tests. Confirm the fan(s) are responding to changes in BAS/VFD input. Raise and Lower the set-points
- Confirm the fan(s) are stable after each set-point change and that they are not hunting.
- Confirm that there are no unusual vibration or sounds from the fan(s).
- Perform a fan failure test, if multiple fans are used and that a fan loss still allows for system operation. Use the approved submittal and fan curves to confirm performance.
- Note: Fan with starters and no drives are fixed CFM set by the balancer.

Cx Operational Tests (Heating Coil)

- After confirming the fan(s) are at design CFM, perform a heating coil (control valve test) by raising and lowering the HCLAT or DAT setpoint.
- Confirm the change in valve position and a change in LAT from the coil. Confirm the coil “Delta T” is at or near design.
- Note the supply and return water temperatures, if using hot water.
- Confirm that the temperature is stable after each change of setpoint.
- Confirm the steam traps are operational if using steam.
- Confirm the F&B coil is operational if using a Face and Bypass coil.

Cx Operational Tests (Cooling Coil)

- After confirming the fan(s) are at design CFM, perform a cooling coil (control valve test) by raising and lowering the CCLAT or DAT setpoint.
- Confirm the change in valve position and a change in LAT from the coil. Confirm the coil “Delta T” is at or near design.
- Note the supply and return water temperatures.
- Confirm that the temperature is stable after each change of setpoint.
- Confirm the cooling coil condensate is draining properly.

Cx Operational Tests (Energy Recovery Wheel)

- After confirming the fan(s) are at design CFM, perform a test of the energy recovery system. This will be based on the performance data provided by the vendor and the air temperature entering the wheel.
- Confirm the wheel performance with the vendor, using the vendor software.
- If provide confirm operation using changes in enthalpy.
- Confirm operation in both heating and cooling.
- Confirm the change in rotation speed (if variable speed) and/or “Delta T”.

Cx Operational Tests (Energy Recovery Coil)

- After confirming the fan(s) are at design CFM, perform a test of the energy recovery system. This will be based on the performance data provided by the vendor and the air temperature entering the coil.
- Confirm the coil performance with the vendor, using the vendor software or via the BAS.
- Confirm operation in both heating and cooling.
- Confirm the change “Delta T”.

Cx Operational Tests (Desiccant Wheel)

- After confirming the fan(s) are at design CFM, perform a test of the desiccant wheel. This will be based on the performance data provided by the vendor and the temperature and humidity entering the wheel.
- Confirm the wheel performance with the vendor, using the vendor software or via the BAS.
- Confirm the operation of the wheel, by-pass (if provided) and the operation of the wheel drying function (Electric, Steam, Gas).
- May be done when the season/weather allows of testing

Cx Operational Tests (Humidifier)

- After confirming the fan(s) are at design CFM, perform a test of the humidifier. This may require seasonal testing.
- Perform a humidifier (control valve test) by raising and lowering the LAH or space/return/exhaust set-point.
- Confirm the humidifier performance and confirm the LAH or space/return/exhaust humidity is being maintained.
- Confirm the the humidity level is stable, no signs of spikes or drop.
- May be done when the season/weather allows of testing.

Cx Tests (BAS)

- Confirm that all screens are ready, functional and show a response to changes.
- Review the BAS set-points, alarm values, and trending.
- Test the normal control logic and assure the system is responding to changes in set-points and is stable.
- Test all interlocks (example: AHU to EF's)
- Test all safeties.
- Test all alerts and alarms.
- Check and Test Trending.
- Confirm the unit operation with a smoke detector trip and/or fire alarm activation.

Cx Tests (Additional Functional Test)

- Complete a full building power loss test. How does this impact the AHU and controls?
- Complete a loss of communications test. How does this impact the AHU and controls?
- Assure the final BAS programming is backed up and a recovery file has been provided.
- What is the follow up? 10-month review, seasonal testing?
- Is On-going Commissioning to be done? What is needed to support that?

Possible Issues - AHU

- Coil velocities above allowable (carryover)
- Air stratification.
- Steam absorption distance greater than design.
- Lights not working.
- Fan vibration (balance or VFD Speed)
- Water system(s) to unit not balanced.
- Water to unit incorrect temperature.
- PCV for steam supply not set.
- Motors running above nameplate amps.

Possible Issues - BAS

- Actually, anything is possible!
- Incomplete BAS screens. (Missing screens)
- BAS wiring incomplete.
- Missing BAS sensors.
- Missing or Incorrect logic.
- Points incorrectly mapped.
- Wrong setpoints.
- Missing alarms and trends.
- BAS - VFD issues.

Operational Issues – Documentation and Correction

- Note all issues.
- Stop Testing in required.
- Keep the issues log up to date.
- Be ready to provide input on the problem and how its should be resolved to meet the Cx requirements.
- Involved the A/E if possible.
- If it is an AHU issue, meet with the vendor, CM and/or owner. Identify a path forward, schedule and note the impact on commissioning.
- If it is a utility issue, meet with the Subcontractor and CM. Identify a path forward, schedule and note the impact on commissioning.
- If it is a BAS issue, meet with the BAS vendor and CM. Identify a path forward, schedule and note the impact on commissioning.
- If a general construction issue, meet CM. They will need to identify a path forward, schedule and document the impact on commissioning.

Training

- Assure the CM has generated a training plan.
- Review the Plan. Confirm the training plan has the required information and detail to train the staff.
- Confirm the BAS vendor has provided training.
- BAS provided screen shots. Documented point in time.
- Confirm the staff is properly trained.
- Document the training, video if required. (may be by Cx)
- Required software given to owner.

Maintenance

Sensor calibration.

- The control sensors can drift making for inaccurate control and possibly leading to operational issues. Calibration should be completed at least once a year.

System Inspection.

- Assure PMs are generated and completed.
- Assure training can be provided for new staff. What does the training package look like?



Questions

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