# Exploring the Benefits of Monitoring-based Commissioning

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# AIA Quality Assurance

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# Course Description

Explore the advantages of Monitoring-Based Commissioning (MBCx) and its impact on compliance, safety, operations, and energy consumption. MBCx is a continuous commissioning process that utilizes advanced analytics and real-time monitoring to optimize building performance. MBCx provides many advantages, such as improving indoor air quality, reducing energy costs, and enhancing safety and security. By continuously monitoring critical parameters and analyzing data, MBCx enables facility managers to identify areas for improvement and implement targeted energy efficiency and sustainability strategies. Monitoring-based commissioning analytics provide feedback so systems can be tuned to use as little energy as possible without compromising occupant comfort. As a result, facilities can achieve substantial cost savings while reducing their carbon footprint, contributing to sustainability goals. Real-time monitoring also allows facility managers to proactively adjust and monitor temperature fluctuations, air exchange rates, and filtration efficiency to improve functionality, efficiency, and overall performance. As technology advances, MBCx will play a significant role in shaping the future of design, construction, and operation.

# Learning Objectives

1. Describe the principles of MBCx and how it can improve building performance.
2. Identify the key components of an MBCx system and how they work together to optimize building performance.
3. Evaluate the benefits of MBCx.
4. Analyze case studies of successful MBCx implementations and the lessons learned.

# What is Commissioning?

A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.

# Commissioning Process

- Traditional New Construction Cx
- Retro-Commissioning/Existing Building Commissioning
- Ongoing Cx
- Monitoring-Based Cx

# New Construction Commissioning Process

**Commissioning Process**
**ASHRAE Guideline 0**

- Process
- Building Types
- Types of Commissioning
- Building Turnover

## PREDESIGN

- OPR
- Cx Plan
- Systems Manual Outline
- Training Requirements Outline
- Issues and Resolution Log
- Issues Report
- Predesign Phase Cx Process Report

## DESIGN

- OPR Update
- Basis of Design Update
- Construction Specs for Cx
- Systems Manual Outline-Expanded
- Training Requirements in Specs
- Design Review Comments
- Issues and Resolution Log
- Issues Report
- Design Phase Cx Process Report

## CONSTRUCTION

- OPR Update
- Basis of Design Update
- Cx plan Update
- Submittal Review Comments
- System Coordination Plans
- Prefunctional and Functional Checklists
- Affidavit of Readiness
- Prefunctional Verification
- Functional Performance Testing
- Cx Kickoff Meeting / Controls Integration / Progress Meetings & Minutes
- Training Plans
- Systems Manual
- Issues and Resolution Log
- Issues Report
- Preliminary Construction Cx Process Report
- Final Construction Phase Cx Process Report

## OCCUPANCY & OPERATIONS

- OPR Update
- Basis of Design Update
- Maintenance Program
- Test Procedures
- Test Data Reports
- Issues and Resolution Log
- Issues Report
- Cx Process Report
- Recommissioning Plan
- Warranty Phase Meeting & Report
- Warranty Review

KEY
PHASES
Deliverables

# Existing Building Commissioning Process

- Re-Commissioning
- Retro-Commissioning
- Ongoing Commissioning
- Monitoring-Based Commissioning
- Standards/Guidelines
- Never Been Commissioned

# Monitoring Based Commissioning (MBCx)

- This is not just BMS
- Software Driven
- Empirical live data
- Prioritization & Tuning is Critical
- Automated Process

# Key Elements of a MBCx Program

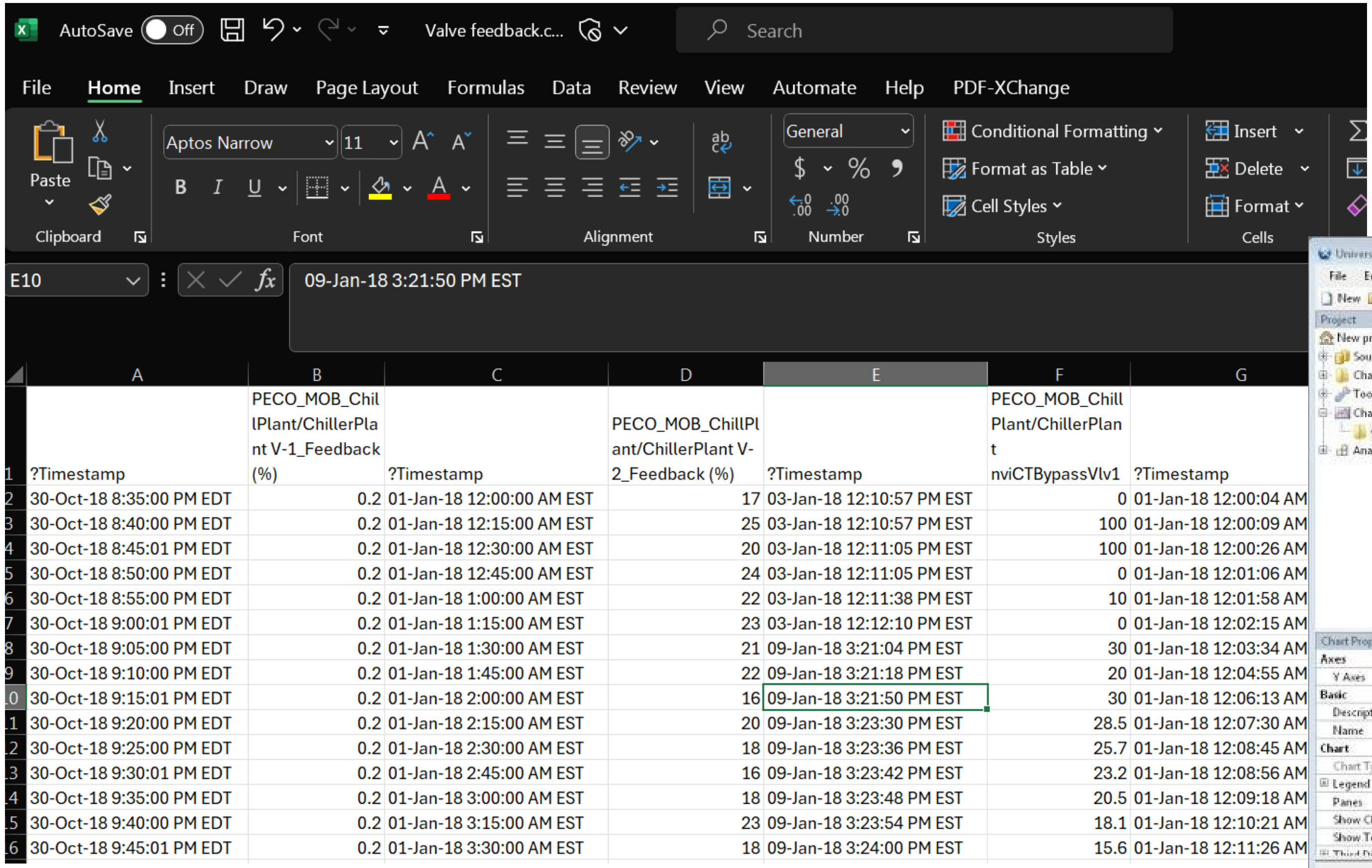
**PHYSICAL**

- Permanent Energy Monitoring
- Energy Management and Information System (EMIS) Software
- Fault Detection and Diagnostics
- Dashboards – Key Performance Indicators

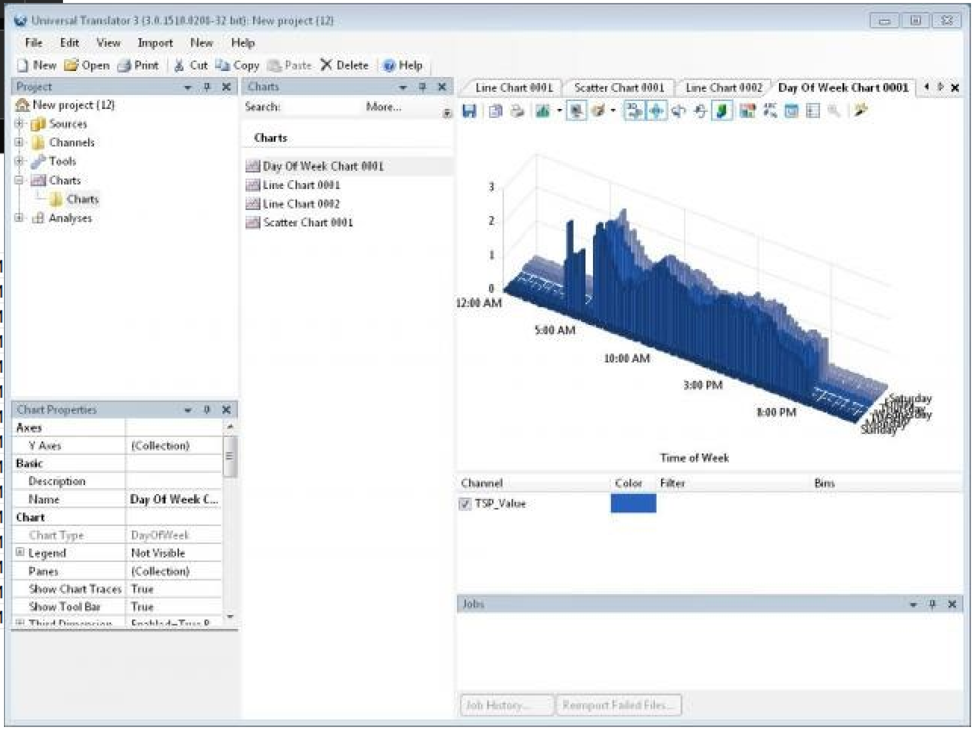
**PROCESS**

- Current Facility Requirements
- Monitoring Action Plan
- Preventative Maintenance and Calibration
- Measurement and Verification

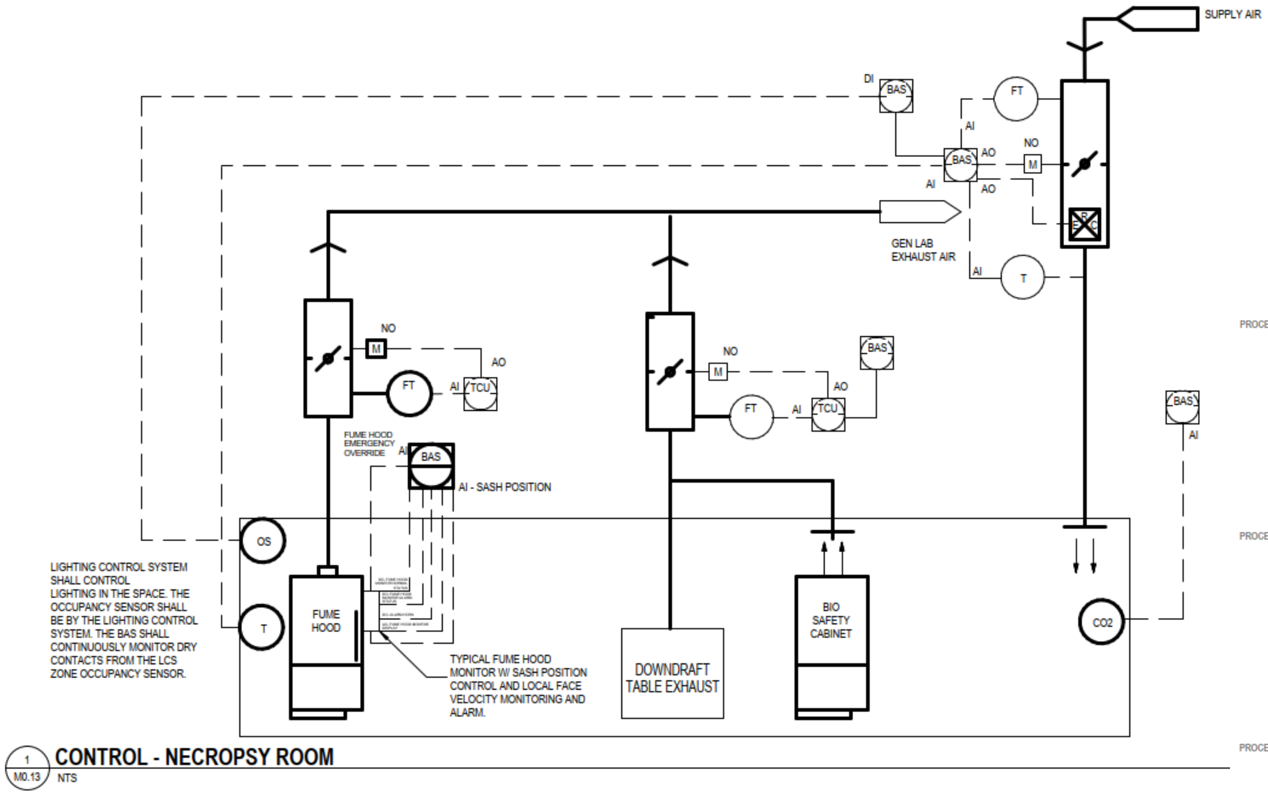
# Manual Ongoing Cx vs MBCx

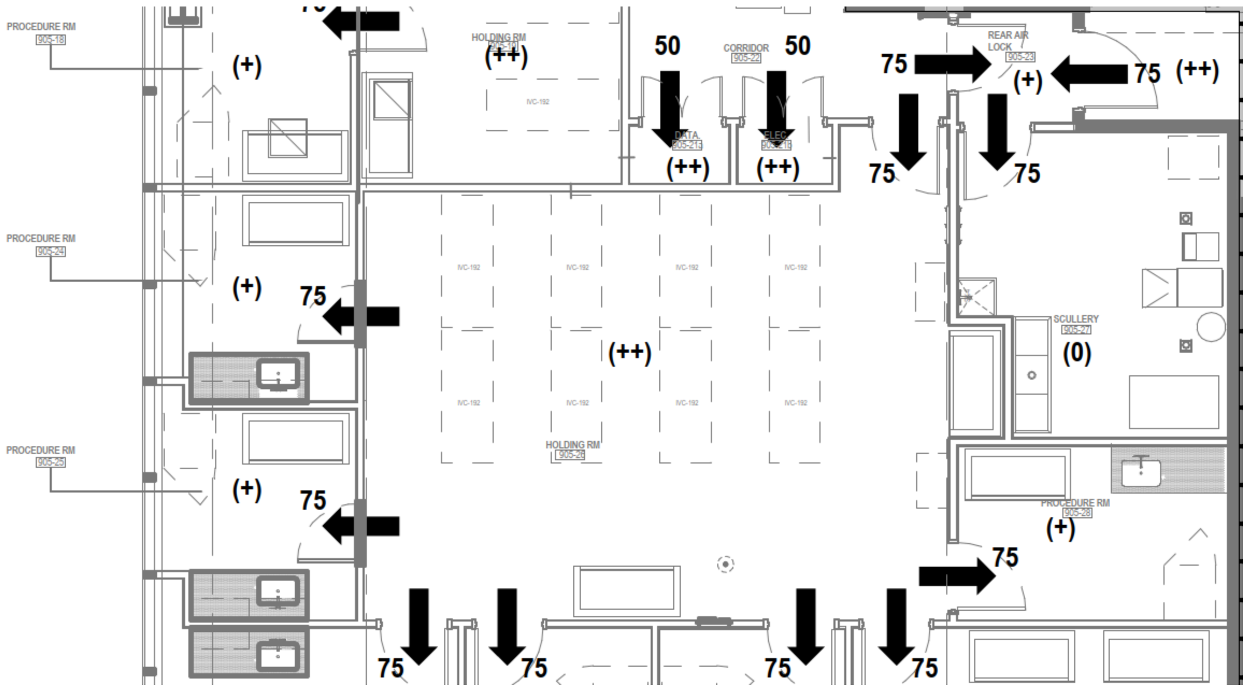


| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 1 | ?Timestamp | PECO_MOB_ChilPlant/ChillerPlant V-1_Feedback (%) | ?Timestamp | PECO_MOB_ChillPlant/ChillerPlant V-2_Feedback (%) | ?Timestamp | PECO_MOB_ChillPlant/ChillerPlant nviCTBypassVlv1 | ?Timestamp |
| 2 | 30-Oct-18 8:35:00 PM EDT | 0.2 | 01-Jan-18 12:00:00 AM EST | 17 | 03-Jan-18 12:10:57 PM EST | 0 | 01-Jan-18 12:00:04 AM |
| 3 | 30-Oct-18 8:40:00 PM EDT | 0.2 | 01-Jan-18 12:15:00 AM EST | 25 | 03-Jan-18 12:10:57 PM EST | 100 | 01-Jan-18 12:00:09 AM |
| 4 | 30-Oct-18 8:45:01 PM EDT | 0.2 | 01-Jan-18 12:30:00 AM EST | 20 | 03-Jan-18 12:11:05 PM EST | 100 | 01-Jan-18 12:00:26 AM |
| 5 | 30-Oct-18 8:50:00 PM EDT | 0.2 | 01-Jan-18 12:45:00 AM EST | 24 | 03-Jan-18 12:11:05 PM EST | 0 | 01-Jan-18 12:01:06 AM |
| 6 | 30-Oct-18 8:55:00 PM EDT | 0.2 | 01-Jan-18 1:00:00 AM EST | 22 | 03-Jan-18 12:11:38 PM EST | 10 | 01-Jan-18 12:01:58 AM |
| 7 | 30-Oct-18 9:00:01 PM EDT | 0.2 | 01-Jan-18 1:15:00 AM EST | 23 | 03-Jan-18 12:12:10 PM EST | 0 | 01-Jan-18 12:02:15 AM |
| 8 | 30-Oct-18 9:05:00 PM EDT | 0.2 | 01-Jan-18 1:30:00 AM EST | 21 | 09-Jan-18 3:21:04 PM EST | 30 | 01-Jan-18 12:03:34 AM |
| 9 | 30-Oct-18 9:10:00 PM EDT | 0.2 | 01-Jan-18 1:45:00 AM EST | 22 | 09-Jan-18 3:21:18 PM EST | 20 | 01-Jan-18 12:04:55 AM |
| 10 | 30-Oct-18 9:15:01 PM EDT | 0.2 | 01-Jan-18 2:00:00 AM EST | 16 | 09-Jan-18 3:21:50 PM EST | 30 | 01-Jan-18 12:06:13 AM |
| 11 | 30-Oct-18 9:20:00 PM EDT | 0.2 | 01-Jan-18 2:15:00 AM EST | 20 | 09-Jan-18 3:23:30 PM EST | 28.5 | 01-Jan-18 12:07:30 AM |
| 12 | 30-Oct-18 9:25:00 PM EDT | 0.2 | 01-Jan-18 2:30:00 AM EST | 18 | 09-Jan-18 3:23:36 PM EST | 25.7 | 01-Jan-18 12:08:45 AM |
| 13 | 30-Oct-18 9:30:01 PM EDT | 0.2 | 01-Jan-18 2:45:00 AM EST | 16 | 09-Jan-18 3:23:42 PM EST | 23.2 | 01-Jan-18 12:08:56 AM |
| 14 | 30-Oct-18 9:35:00 PM EDT | 0.2 | 01-Jan-18 3:00:00 AM EST | 18 | 09-Jan-18 3:23:48 PM EST | 20.5 | 01-Jan-18 12:09:18 AM |
| 15 | 30-Oct-18 9:40:00 PM EDT | 0.2 | 01-Jan-18 3:15:00 AM EST | 23 | 09-Jan-18 3:23:54 PM EST | 18.1 | 01-Jan-18 12:10:21 AM |
| 16 | 30-Oct-18 9:45:01 PM EDT | 0.2 | 01-Jan-18 3:30:00 AM EST | 18 | 09-Jan-18 3:24:00 PM EST | 15.6 | 01-Jan-18 12:11:26 AM |



# Application of MBCx



# Safety Classification – Air Changes per Hour

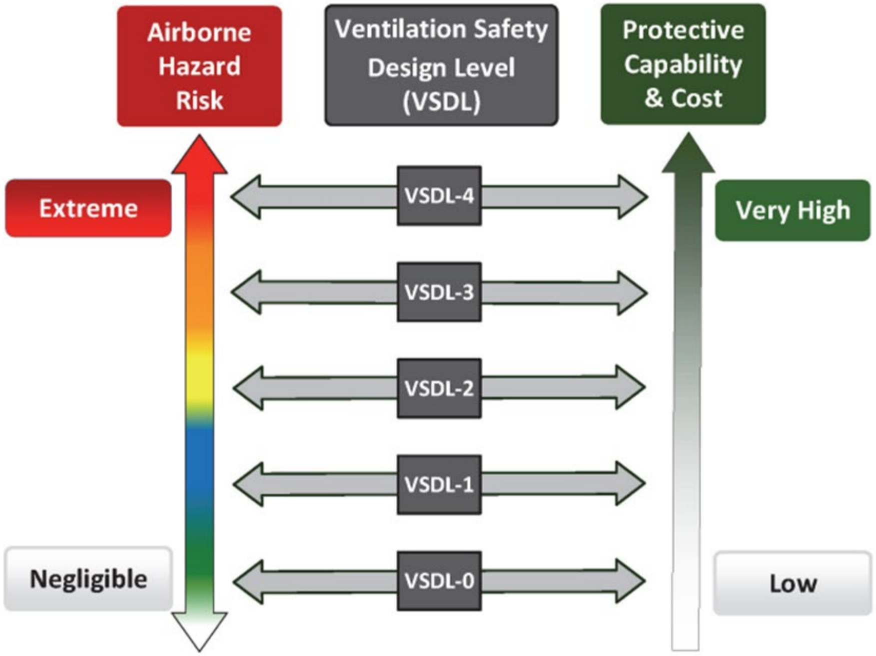



**Figure 2** Risks associated with airborne hazards and the levels of protection associated with the range of LVDLs.

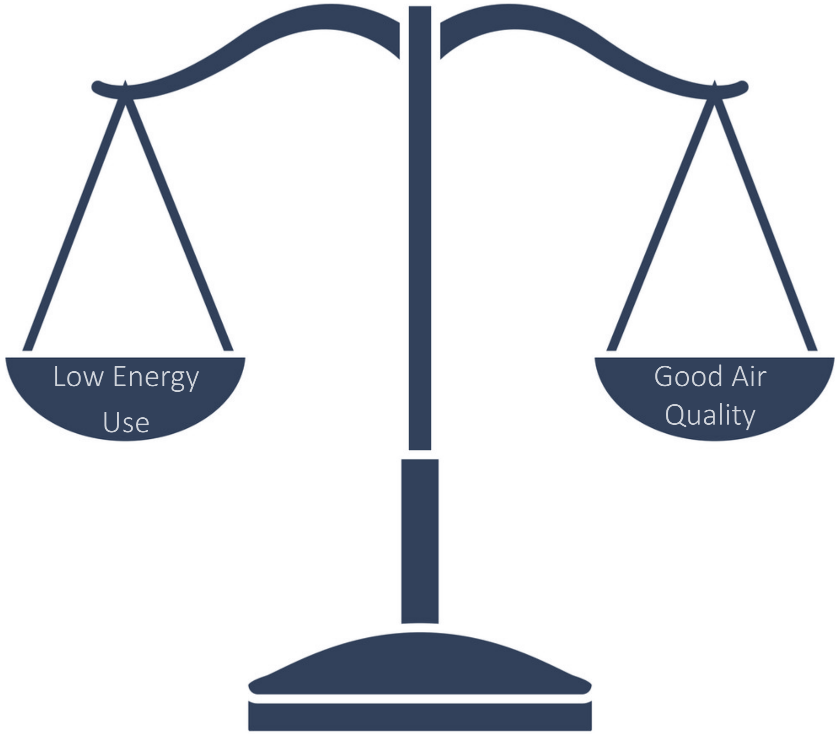
- Engage
- Define
- Prove

# Performance: *Air Quality – Compliance*

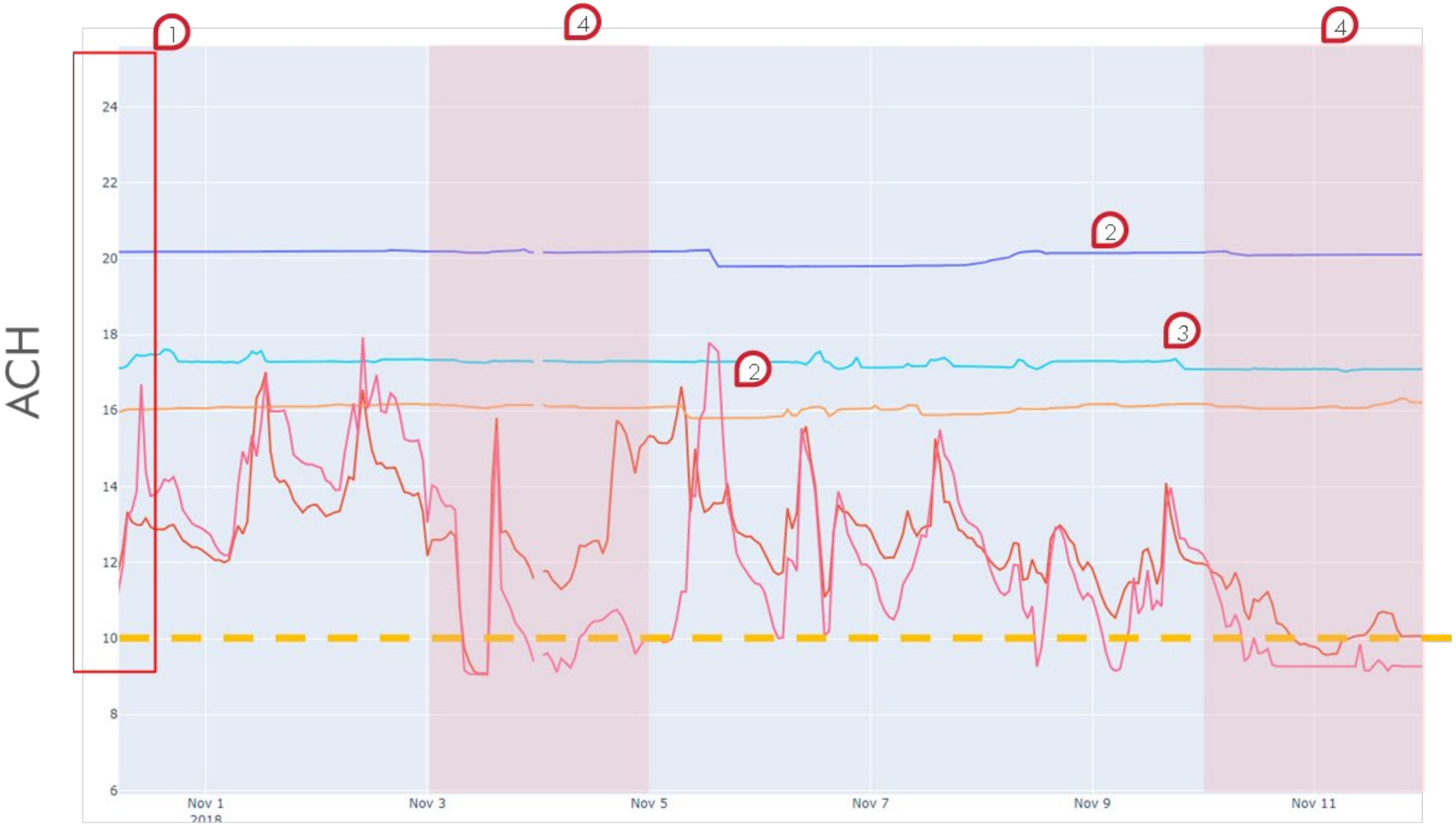
- AHJ-ACH, Pressurization (NIH, AAALAC) BSL3
- Compounding Pharmacy – USP 800, FGI
- Design to installation to verification (ACH and pressure relationships)
- Initial verification relies on instrumentation measurement.
- Ongoing verification requires sensors to maintain calibration.
- Smart air quality sensing system (ie Aircuity).

# Centralized Indoor Air Quality System

- Dynamic Airflow Control
- Lowest Energy Consumption
- Air Quality to Meet Occupant Needs
- Not Perfect

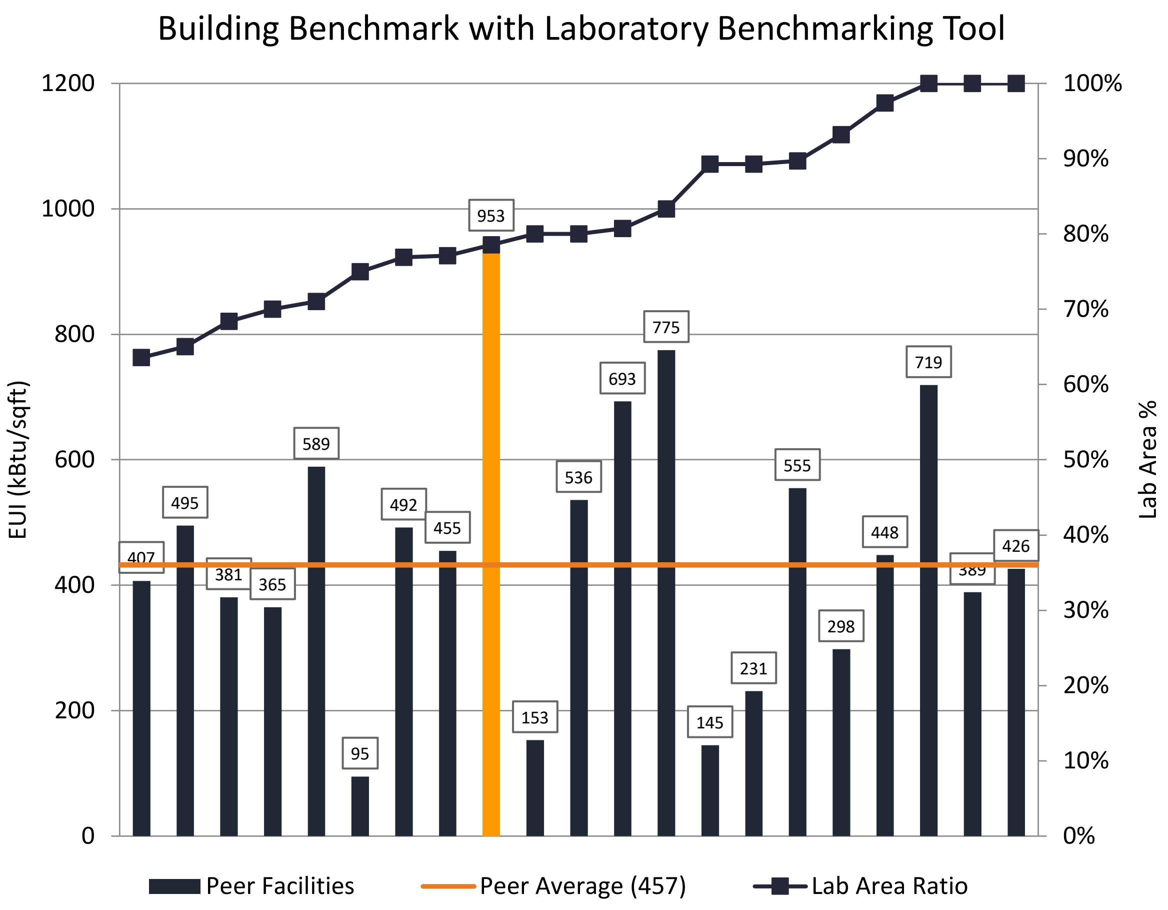


# Performance – Indoor Air Quality Monitoring



# Performance: *Energy Consumption*

- Safety
- Reliability
- Energy Use Intensity



# Compliance: *Air Quality and Energy Efficiency*

- AHJ-ACH, Pressurization (NIH, AAALAC) BSL3
- Compounding Pharmacy – USP 800, FGI
- BEPP and other

City of Philadelphia

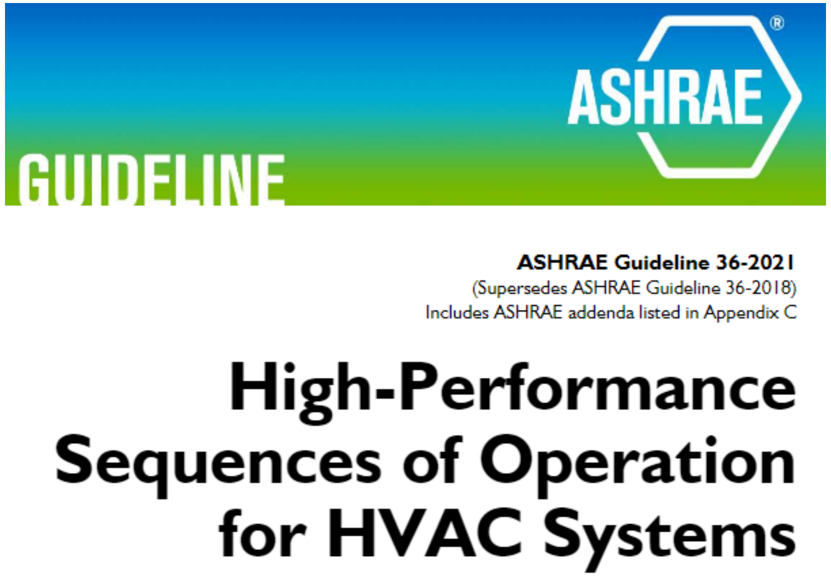
Building Energy Performance Policy

THE CITY OF PHILADELPHIA OFFICE OF SUSTAINABILITY

Environment Health & Safety

# Fault Detection - ASHRAE 36

- This guideline describes functional tests that, when performed, will confirm implementation of the sequences of operation.


ASHRAE

GUIDELINE

**ASHRAE Guideline 36-2021**
(Supersedes ASHRAE Guideline 36-2018)
Includes ASHRAE addenda listed in Appendix C

**High-Performance Sequences of Operation for HVAC Systems**

**Table 5.16.14.8 VAV AHU Fault Conditions**

| | | | |
|---|---|---|---|
| **FC#1** | **Equation** | $DSP_{AVG} < DSPSP - \varepsilon_{DSP}$<br>and<br>$VFDSPD \geq 99\% - \varepsilon_{VFDSPD}$ | **Applies to OS #1 – #5** |
| | **Description** | Duct static pressure is too low with fan at full speed | |
| | **Possible Diagnosis** | Problem with VFD<br>Mechanical problem with fan<br>Fan undersized<br>SAT Setpoint too high (too much zone demand) | |

# Analytic Library

| Eqpt | Alert Name | Description of Analysis | Built? | Date Built | Parameters | Tuned? | Vetted | Notes | Equip / Location |
|---|---|---|---|---|---|---|---|---|---|
| AHUs | AC_ConstEna | AHU Fan running continuously | Yes | 4/5/2022 | FanSts = True for 36hrs | Yes | Yes | Currently for all fans | All AC Units |
| AHUs | AC_FreqCycle | Fan turns on and off excessively. | Yes | 7/22/2022 | More than 6 sts COVs in 3 hrs | Yes | Yes | Currently for all fans | All AC Units |
| AHUs | AC_SupplyFanHighSpeed | AHU fan at 100% for an extended time. | Yes | 11/16/2021 | SFan On, Spd >99% for 3.5 hr | Yes | Yes | added fallback to speed value (SDG) 1/19/22 | All AC Units |
| AHUs | AC_SupplyFanLowSpeed | AHU fan at 0% for an extended time. | Yes | 11/17/2021 | SFan On, Spd < 1% for 3 hr | Yes | Yes | added fallback to speed value (SDG 1/19/22) | All AC Units |
| AHUs | AC_DatOutOfRange | AHU DAT off of setpoint for an extended time. | Yes | 10/27/2021 | +/- 3degF for more than 2 hr | Yes | Yes | | All AC Units |
| AHUs | AC_HighClgVlvPos | AHU cooling valve at 100% for an extended time. | Yes | 10/20/2021 | VlvPos > 99% for 3 hrs | Yes | Yes | | S27: AC01, AC02, AC05, AC06<br>N6: AC07, AC09, AC11, AC12, AC13, AC14, AC15, AC16, AC19 |
| AHUs | AC_ClgVlvLeak | AHU cooling coil reducing the air temperature while the valve has been closed for an extended time. | Yes | 10/27/2021 | SFan On, Clg Vlv Closed, Dat - MAT > 3DegF for 2hr | Yes | Yes | | S27: AC01, AC02, AC03, AC05, AC06<br>N6: AC07, AC09, AC10, AC11, AC12, AC13, AC14, AC15, AC16, AC19 |
| AHUs | AC_HighHtgVlvPos | AHU htg valve at 100% for an extended time. | Yes | 10/20/2021 | VlvPos > 99% for 3 hrs | Yes | Yes | | S27: AC03 N6: ~~AC07~~, AC09, AC10, AC15<br>Lobby Units |
| AHUs | AC_HtgVlvLeak | AHU heating coil increasing the air temperature while the valve has been closed for an extended time. | Yes | 11/2/2021 | SFan On, Htg Vlv Closed, MAT - DAT > 3DegF for 2hr | Yes | Yes | revisit nodes<br>boilers are only available for part of the year | S27: AC03<br>N6: ~~AC07~~, AC09, AC10, AC15<br>Lobby Units |
| AHUs | AC_SimulHtgClg | Heating and Cooling coil valves both open for an extended time. | Yes | 11/17/2021 | Both Valves >= 10% for 2 hrs | Yes | Yes | | |
| AHUs | AC_HighPreheatTemp | AHU preheat coil increasing the air temperature while the valve has been closed for an extended time. | Yes | 11/17/2021 | SFan On, OA Below 55, Preheat Cls, Coil DA Hi Temp | Yes | Yes | rev<br>is<br>ye | |
| Chillers | Chlr_HighSupTemp | Chilled water supply temperature significantly above setpoint for an extended time. | Yes | 11/2/2021 | CHW Supply Temp (average of three lines) > 46 for 1hr | Yes | Yes | | |
| Chillers | Chlr_LowSupplyTemp | Chilled water supply temperature significantly below setpoint for an extended time. | Yes | 11/2/2021 | CHW Supply Temp (average of three lines) < 40 for 1hr | Yes | Yes | | |

**Fault Detection and Diagnostics**

| Faults | FDD Tool Analysis |
|---|---|
| ***General Faults*** | |
| Schedules | Check if equipment is operating out of hours. |
| Manual override | Identify overrides that should not be in place. |
| Controllers | Compare controller output setpoints to the actual condition to find failed devices.<br>Determine the stability of controllers. |
| Dampers | Identify if a damper is stuck open, closed, or at a fixed position, or leaking<br>(i.e., compare mixed air temp to return air temp with outdoor air damper closed). |
| Cooling/heating/precooling/preheating/ reheating valve and coils | Identify if a valve is stuck or leaking.<br>Identify a fouled or blocked coil.<br>(i.e., a temperature difference exists across a coil when a valve is shut or not achieving a desired temperature drop across a coil when a valve is open.) |
| ***Variable Air Volume (VAV) box faults*** | |
| Sensors | Critical sensors: space temperature, relative humidity, carbon dioxide, airflow rate<br>Detect if the sensor is outside of a feasible range, flat-lining, bias, drift, or failure. |
| Thermostat occupied/unoccupied cooling/heating setpoints | Detect if the space cooling/heating setpoints deadband is not great enough (i.e., less than 3°F). |

# Advanced Technologies – Facilities

**Table 3 — SCU Open I/O Configuration**

| | INPUT/OUTPUT TYPE | TYPE OF I/O | I/O CHANNEL (CONNECTION PIN) | I/O CONFIGURATION |
|---|---|---|---|---|
| | **INPUTS** | | | |
| UC OPEN | Occupancy Override | Dry Contact | UI-12-19 and 20 | DI |
| | Duct Static Pressure Sensor | 0-5 vdc | UI-11-17 and 18 | AI |
| | Compressor Status (Compressor 4) | IEM 2 | UI-10-16 and 17 | DI |
| | Compressor Status (Compressors 1-3) | IEM 1 | UI-09-14 and 15 | DI |
| | Return Air Sensors | 10K Type II | UI-08-13 and 14 | AI |
| | Entering Water Temperature | 10K Type II | UI-07-11 and 12 | AI |
| | Supply Air Temperature Sensor | 10K Type II | UI-06-10 and 11 | AI |
| | Relative Humidity Sensor (Required for dehum. operation.) | 0-5 vdc | UI-05-8 and 9 | AI |
| | $CO_2$ Sensor (Required for demand control ventilation.) | 0-5 vdc | UI-04-7 and 8 | AI |
| | Leaving Water Temperature Sensor | 10K Type II | UI-03-5 and 6 | AI |
| | UPM II (Compressors 2 and 4) | Dry Contact | UI-02-2 and 4 | DI |
| | UPM II (Compressors 1 and 3) | Dry Contact | UI-01-2 and 3 | DI |
| | **OUTPUTS** | | | |
| | Not Available | — | AO-6-11 and 12 | AO |
| | Outdoor Air Damper | 0-10 vdc | AO-4-7 and 8 | AO |
| | Auxiliary Hot Water Heat | 0-10 vdc | | |
| | Modulating Hot Gas Re-heat Valves | 0-10 vdc | | |
| | Fan Speed (VFD Drive Terminal Strip AI-1) | 0-10 vdc | | |

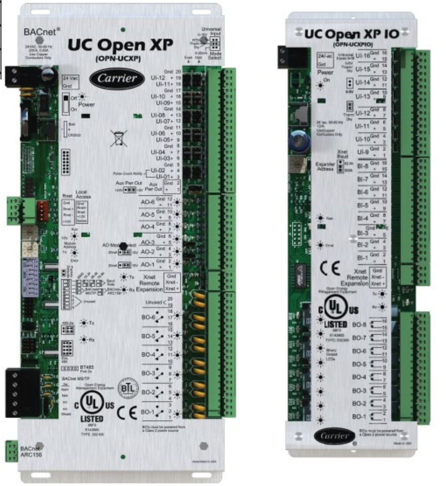
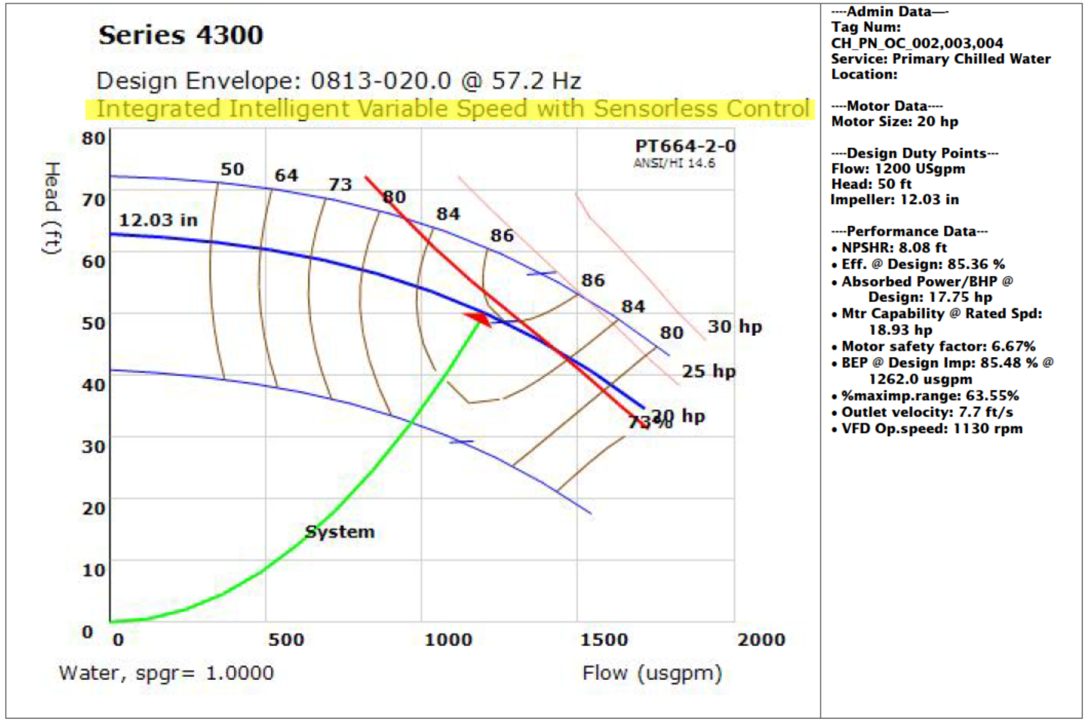



**Fig. 1 — UC Open Control Module**

**Table 1 — UC Open XP Specifications**

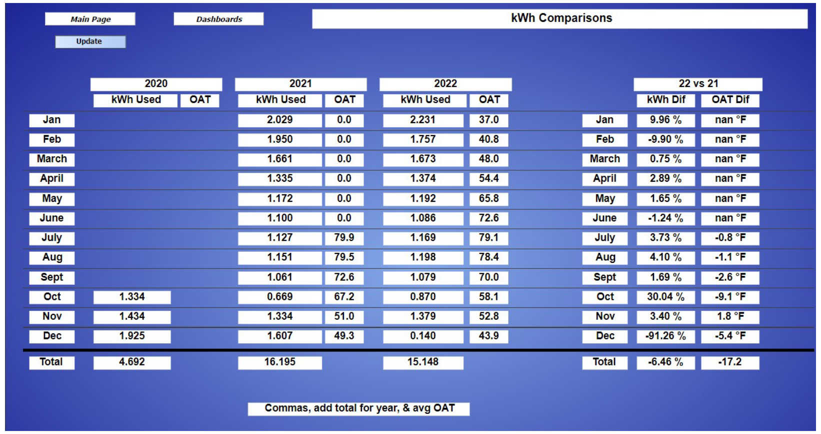
**Performance curve**



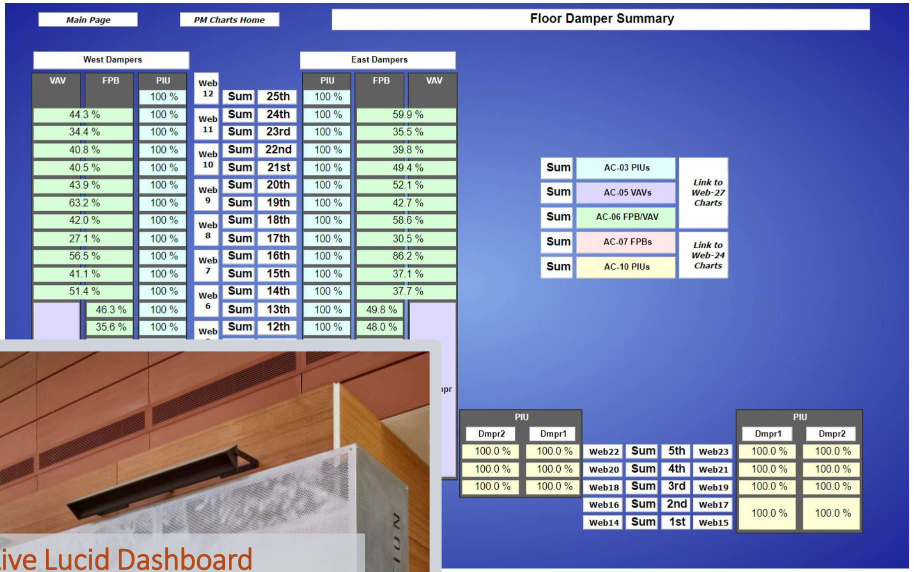
# Continuous Cx Tuning to Maintain Performance

- Fault Detection and Diagnostics
- Systems and Equipment
- Dashboards and Key Performance Indicators

# Dashboards




| | 2020 | | 2021 | | 2022 | | | 22 vs 21 | |
|---|---|---|---|---|---|---|---|---|---|
| | kWh Used | OAT | kWh Used | OAT | kWh Used | OAT | | kWh Dif | OAT Dif |
| Jan | | | 2.029 | 0.0 | 2.231 | 37.0 | Jan | 9.96 % | nan °F |
| Feb | | | 1.950 | 0.0 | 1.757 | 40.8 | Feb | -9.90 % | nan °F |
| March | | | 1.661 | 0.0 | 1.673 | 48.0 | March | 0.75 % | nan °F |
| April | | | 1.335 | 0.0 | 1.374 | 54.4 | April | 2.89 % | nan °F |
| May | | | 1.172 | 0.0 | 1.192 | 65.8 | May | 1.65 % | nan °F |
| June | | | 1.100 | 0.0 | 1.086 | 72.6 | June | -1.24 % | nan °F |
| July | | | 1.127 | 79.9 | 1.169 | 79.1 | July | 3.73 % | -0.8 °F |
| Aug | | | 1.151 | 79.5 | 1.198 | 78.4 | Aug | 4.10 % | -1.1 °F |
| Sept | | | 1.061 | 72.6 | 1.079 | 70.0 | Sept | 1.69 % | -2.6 °F |
| Oct | 1.334 | | 0.669 | 67.2 | 0.870 | 58.1 | Oct | 30.04 % | -9.1 °F |
| Nov | 1.434 | | 1.334 | 51.0 | 1.379 | 52.8 | Nov | 3.40 % | 1.8 °F |
| Dec | 1.925 | | 1.607 | 49.3 | 0.140 | 43.9 | Dec | -91.26 % | -5.4 °F |
| Total | 4.692 | | 16.195 | | 15.148 | | Total | -6.46 % | -17.2 |

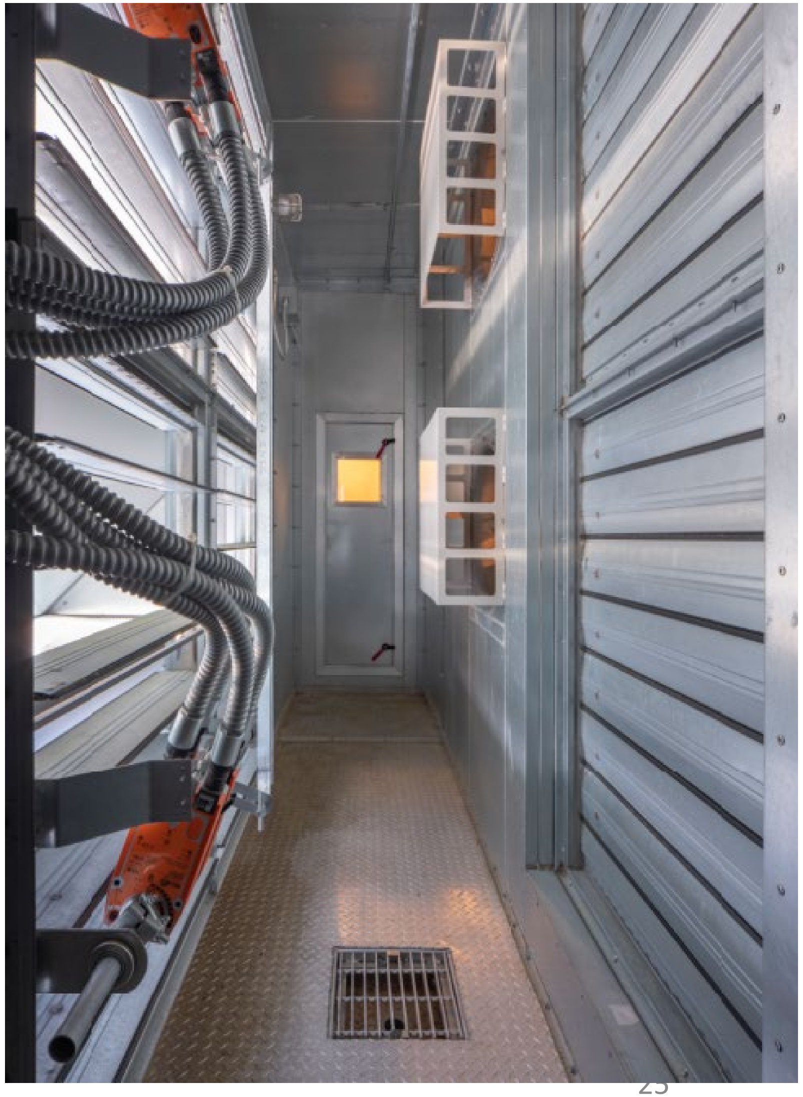



# Methods to Implement

- Building Automation System + Add-On
- Building Automation System + 3rd Party Software
- Integration of Metering
- Procurement

# MBCx Set Up & Maintenance

- Initial Checkout
- Continuous Tuning
- Integrated with CMMS



# New Construction Cx: *Setting up for MBCx*

## AIR HANDLING UNIT
## AUTOMATIC FAULT DETECTION AND DIAGNOSTICS

| | | | |
|---|---|---|---|
| Client | | Eqpt ID: | |
| Project | | Type: | |
| Address | | Model No. | |
| Location | | Manuf. | |

**INSTRUCTIONS**

**Automatic Fault Detection and Diagnostics (AFDD):**

The AFDD routines for the air handling units are continually assessing the air handling unit performance by comparing the values of the BAS inputs and outputs to potential fault conditions. The potential fault conditions is assessed at any point dependent upon the operating state (OS) of the air handling unit, as determined by the position of the cooling and heating valves and the economizer damper. There are five OS and they are as follows:

OS 1: Heating
OS 2: Free cooling, modulating outside air
OS 3: Mechanical & economizer cooling
OS 4: Mechanical cooling, minimum outside air
OS 5: Unknown or dehumidification

**OPERATING STATE 1 (HEATING)**

**FC#1: Duct static pressure too low with the fan at full speed**

| | | | |
|---|---|---|---|
| 1. Decrease supply and return fans speed commensurately to the lowest possible speed (UOS) decrease supply and return fan speed to 15 Hz. | ☐ YES | ☐ NO | ☐ N/A |
| 2. Safely Open AHU doors on the downstream side of the supply side of the fan(s). | ☐ YES | ☐ NO | ☐ N/A |
| 3. Safely open AHU door on the suction side of the return side of the fan(s) | ☐ YES | ☐ NO | ☐ N/A |
| 4. Increase supply and return air fan speeds by increments of 15 Hz until supply fan is at 60 Hz. | ☐ YES | ☐ NO | ☐ N/A |

# Commissioning: Day 1, Day 2, Day 100

- Baseline Functionality
- First-Year Tuning
- Performance Persistence

**DOAS 3-1**
**FUNCTIONAL FORM**

| | |
|---|---|
| Client | Unit Tag |
| Project | Location |
| Project No. | Date |
| Address | Performed By |

**GENERAL**

**Pre-Requisite Documentation**

Contractor to make available as-built documentation as required be project specifications for commissioning provider to review. (red-lines acceptable)

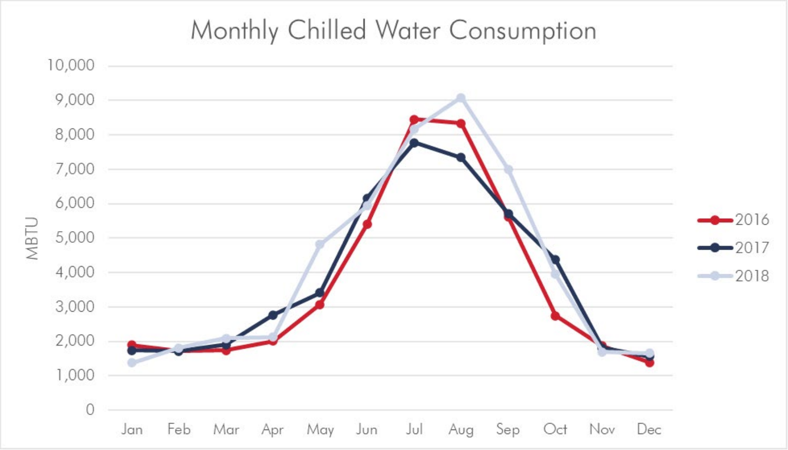
| | |
|---|---|
| 1. As built Documentation | No |

**MAINTENANCE VERIFICATION**

**Maintenance Verification**

Verify preventive maintenance activities can be accomplished.

| | |
|---|---|
| 1. All unit access doors are accessible | Yes |
| 2. Filter is accessible | Yes |
| 3. All dampers and actuators are accessible. | Yes |
| 4. All fans motors and VFDs are accessible. | Yes |



# Practical Implementation

## Work Order Details

**5708639: MOB 6N WEST AHU OPERATION CK AHU00019**

**Task IDs**

| Task ID | Description | Status | Measurement Point | Value | Date | Observations |
|---|---|---|---|---|---|---|
| 5 | ASSEMBLE OPEN/METERED STOCK MATERIALS: | COMP | | 0 | | |
| | NOTE: 1. Open Stock materials ARE NOT to be listed, unless shown on Materials tab of plan. 2. Metered materials (Truck Stock) must be listed on Work Order ONLY when NEW container is taken from storeroom. 3. Controlled items (on Materials tab) must ALWAYS be listed on Work Order. 4. When recording items on WO: Enter quantity TAKEN FROM STOREROOM Select from correct storeroom If item was NOT taken from a storeroom, enter as a NONSTOCK. This includes anything previously gotten out of storeroom and kept on truck or at another location. OPEN STOCK: ABS-1001 RAGS BOX SCOTT METERED MATERIALS: PNT-1001 PAINT, ZINC GALVANIZER 16 OZ SPRAY CAN OIL-1001 LUBE, DRY, SILICON AEROSOL #654-157 CHM-0002 ALGAECIDE, CONDENSATE TABLET #476-134 TOOLS: ME-005 VACUUM CLEANER, WET VAC | | | | | |
| 10 | ALWAYS WEAR PROPER PPE, AS DETAILED IN | COMP | | 0 | | |
| | COMPANY GUIDELINES. | | | | | |
| 15 | MAKE REQUIRED CALLS & LOG. DO TAILBOARD BRIEFING. | COMP | | 0 | | |
| 20 | IF WORK WILL IMPACT "CUSTOMER", NOTIFY | COMP | | 0 | | |
| | AFFECTED PERSONS OR AREAS. | | | | | |
| 30 | INSPECT OVERALL CONDITION OF | COMP | | 0 | | |
| | CABINET AND DUCTWORK. LOOK FOR RUST/CORROSION, MISSING HARDWARE, DAMAGE OR HOLES, LEAKS, DAMAGED INSULATION | | | | | |
| 40 | INSPECT MOTOR, STARTER, CONTROLS, | COMP | | 0 | | |
| | AND SELECTOR SWITCH FOR AUTO WARNING OR INDICATOR LIGHTS. | | | | | |

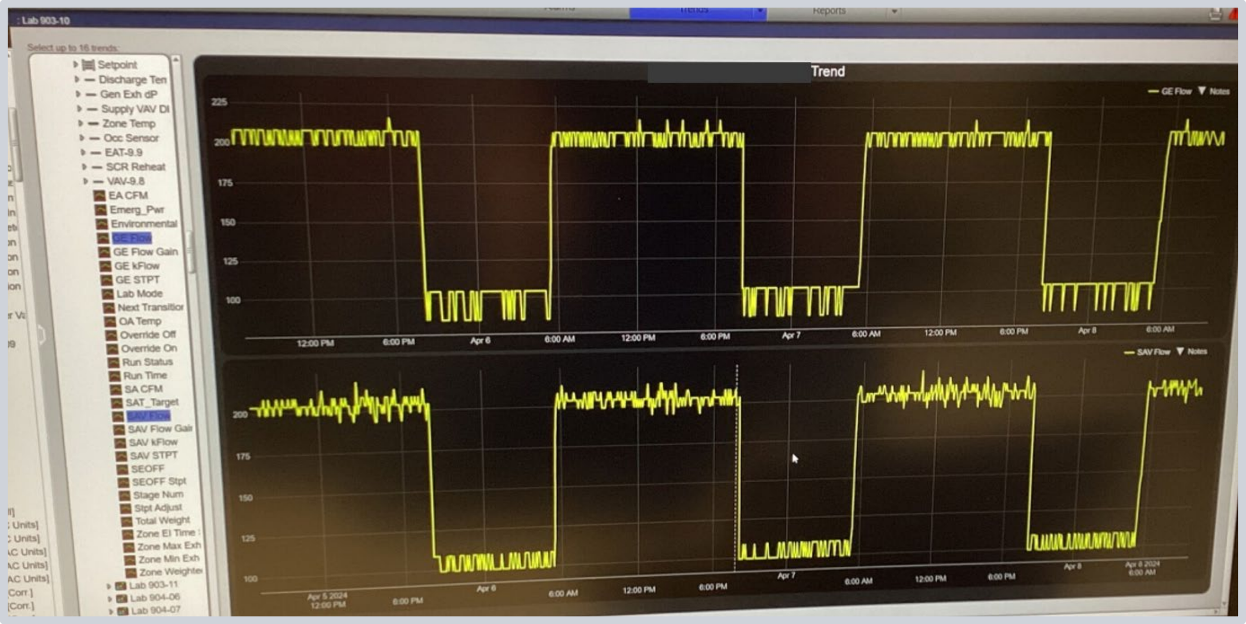
STANDARD

**ANSI/ASHRAE/ACCA Standard 180-2018**
(Supersedes ANSI/ASHRAE/ACCA Standard 180-2012)

# Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems

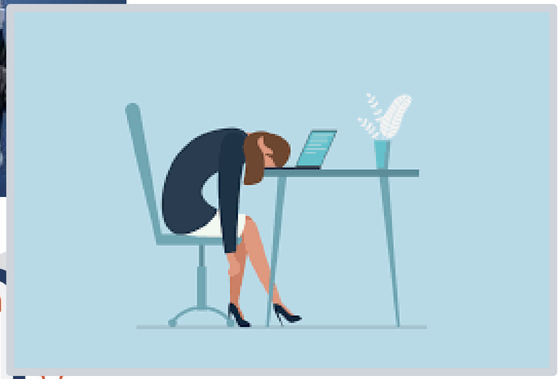
# Maintain the Environment/Equipment on a Continuous Basis

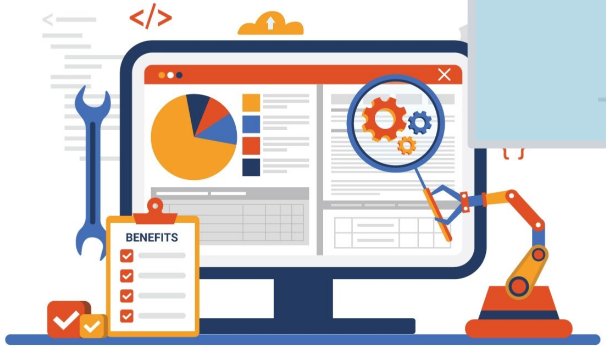
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 422 | March Total | 362 | | | 17 | | |
| K | MOB Equipment | K | MOB Alert Types | | K | CSSB Equip | K | CSSB Alert Type |
| 12 | AC09__PECO_MOB_N6_Web24 | 97 | TU_SpaceTempOor4UnoccHtg | | 1 | ERH_4_10__ERHs_PECO_ChristianSt | 10 | FCU_SpaceTempOor2OccClg |
| 12 | VAV23002__PECO_MOB_23_24_Web11 | 65 | TU_SpaceTempOor3OccHtg | | 2 | ERH_4_15__ERHs_PECO_ChristianSt | 1 | FCU_SpaceTempOor3OccHtg |
| 11 | AC03__PECO_MOB_S27 | 47 | TU_SpaceTempOor2OccClg | | 1 | ERH_4_6__ERHs_PECO_ChristianSt | 6 | RH_SpaceTempOor3OccHtg |
| 9 | AC10__PECO_MOB_N6_Web24 | 26 | TU_DominantZoneDamper | | 2 | ERH_4_7__ERHs_PECO_ChristianSt | | |
| 8 | FPBN3025__PECO_MOB_N3W_Web18 | 20 | TU_HighSpaceCO2 | | 5 | FCU_M_18_4__FCUs_PECO_ChristianSt | | |
| 7 | VAV18004__PECO_MOB_17_18_Web8 | 19 | AC_DatOutOfRange | | 1 | FCU_M_19_1__FCUs_PECO_ChristianSt | | |
| 6 | FPBN2001A__PECO_MOB_N2W_Web16 | 14 | PIU_SpaceTempOor2OccClg | | 1 | FCU_M_20_1__FCUs_PECO_ChristianSt | | |
| 6 | FPBN2004__PECO_MOB_N2W_Web16 | 13 | AC_HtgVlvLeak | | 2 | FCU_M_21_1__FCUs_PECO_ChristianSt | | |
| 6 | FPBN3008__PECO_MOB_N3W_Web18 | 9 | EDH_SpaceTempOor3OccHtg | | 1 | FCU_M_22_1__FCUs_PECO_ChristianSt | | |
| 6 | PChwsTemp_T23__PECO_ChillPlant | 8 | PIU_SpaceTempOor3OccHtg | | 1 | FCU_M_6_1__FCUs_PECO_ChristianSt | | |
| 6 | VAV26013__PECO_MOB_25_26_Web12 | 7 | AC_HighClgVlvPos | | 17 | | | |
| 5 | AC05__PECO_MOB_S27 | 6 | AC_ClgVlvLeak | | | | | |
| 5 | FPB08001__PECO_MOB_7_8_Web3 | 6 | Chlr_HighSupTemp | | | | | |
| 5 | FPB09005__PECO_MOB_9_10_Web4 | 6 | TU_DischargeTemp_HighLimit | | | | | |
| 5 | FPBN2001B__PECO_MOB_N2W_Web16 | 5 | SLobbyHws_LowSupplyTemp | | | | | |
| 5 | SLobbyBBR__PECO_MOB_4_GS_Web1 | 3 | TU_SpaceTempOor1UnoccClg | | | | | |
| 5 | VAV25005__PECO_MOB_25_26_Web12 | 2 | AC_FreqCycle | | | | | |
| 5 | VAVSG005__PECO_MOB_NG_Web25 | 2 | AC_HighHtgVlvPos | | | | | |
| 4 | AC01__PECO_MOB_S27 | 2 | AC_SimulHtgClg | | | | | |
| 4 | AC11__PECO_MOB_N6_Web24 | 2 | FCU_SpaceTempOor3OccHtg | | | | | |
| 4 | FPB08004__PECO_MOB_7_8_Web3 | 1 | AC_SupplyFanHighSpeed | | | | | |
| 4 | FPB11002__PECO_MOB_11_12_Web5 | 1 | PIU_SpaceTempOor1UnoccClg | | | | | |
| 4 | FPBN1037__PECO_MOB_N1W_Web14 | 1 | TU_LowSpaceCO2 | | | | | |



# Continuous Automated Testing

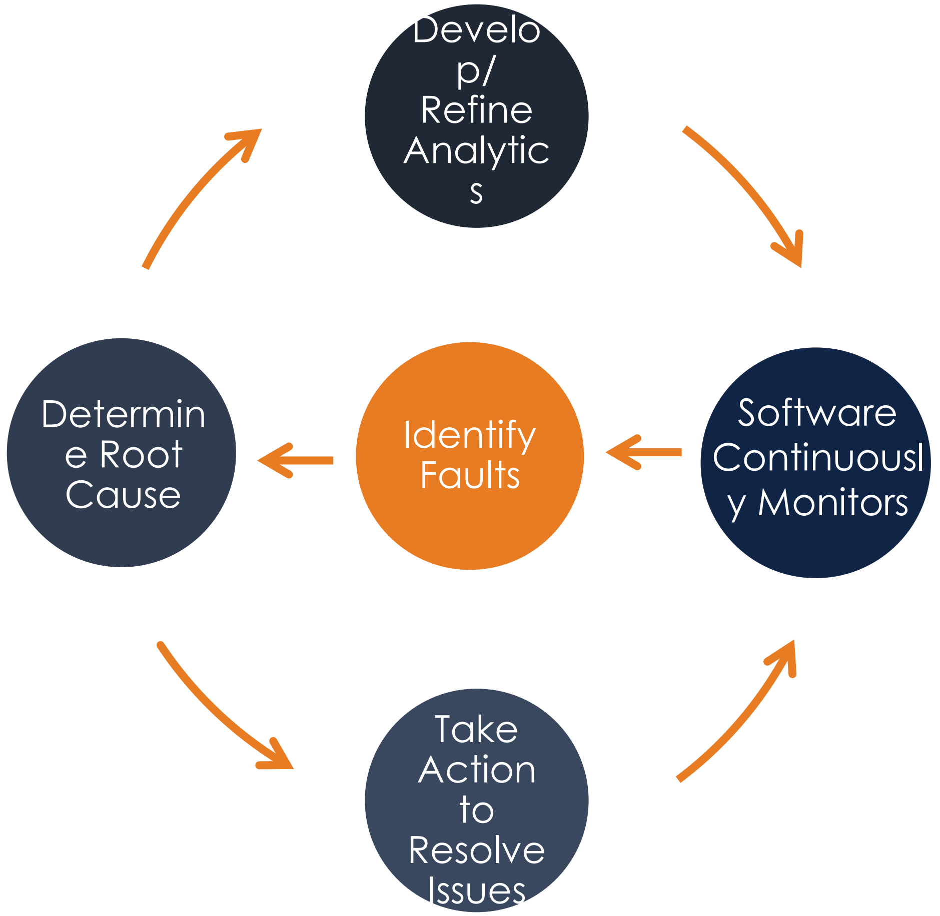
- Let's occupants focus on their work, not the building
- Reduces downtime
- Maintains a safe environment
- Saves $$





# Monitoring-Based Commissioning

- High Performance Buildings
- Leverage Software
- Stakeholders
- Continuous Monitoring
- Flexibility in Program

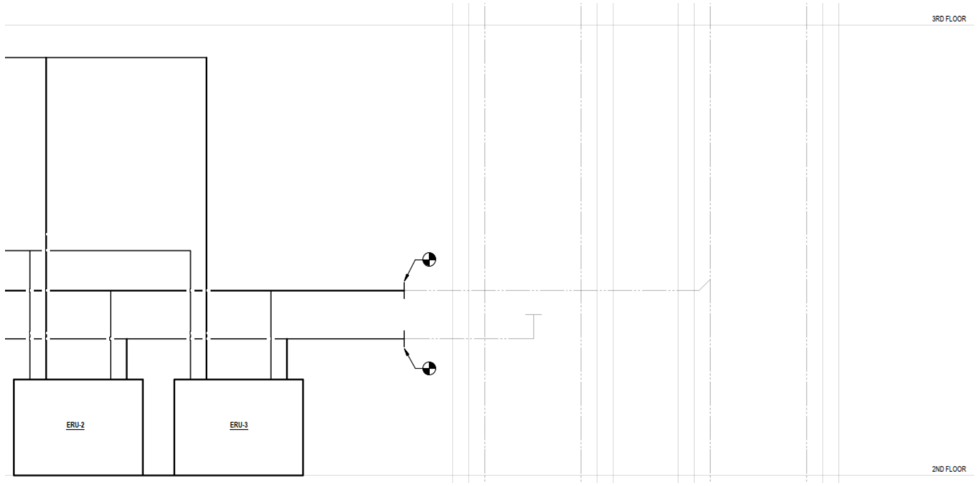


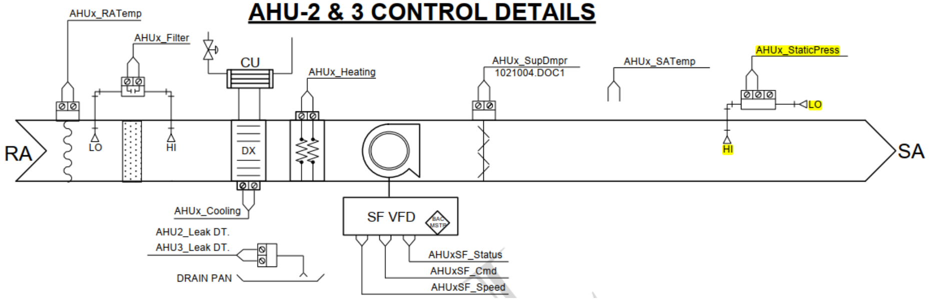
# Tenant Fitout Laboratory Commissioning

- Demand for Lab Space
- Work-from-Home
- Labs as Flexible Workspaces
- Landlord/Tenant Relationship

# Lessons Learned: Tenant Fitout

- Landlord Coordination
- High Volume/Pressure HVAC
- Smart Monitoring for Reliability

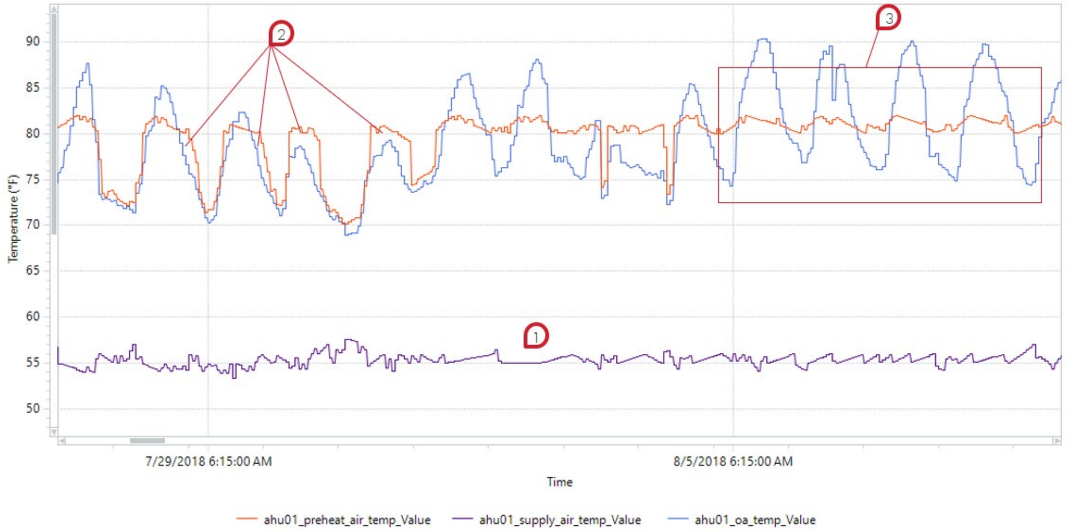


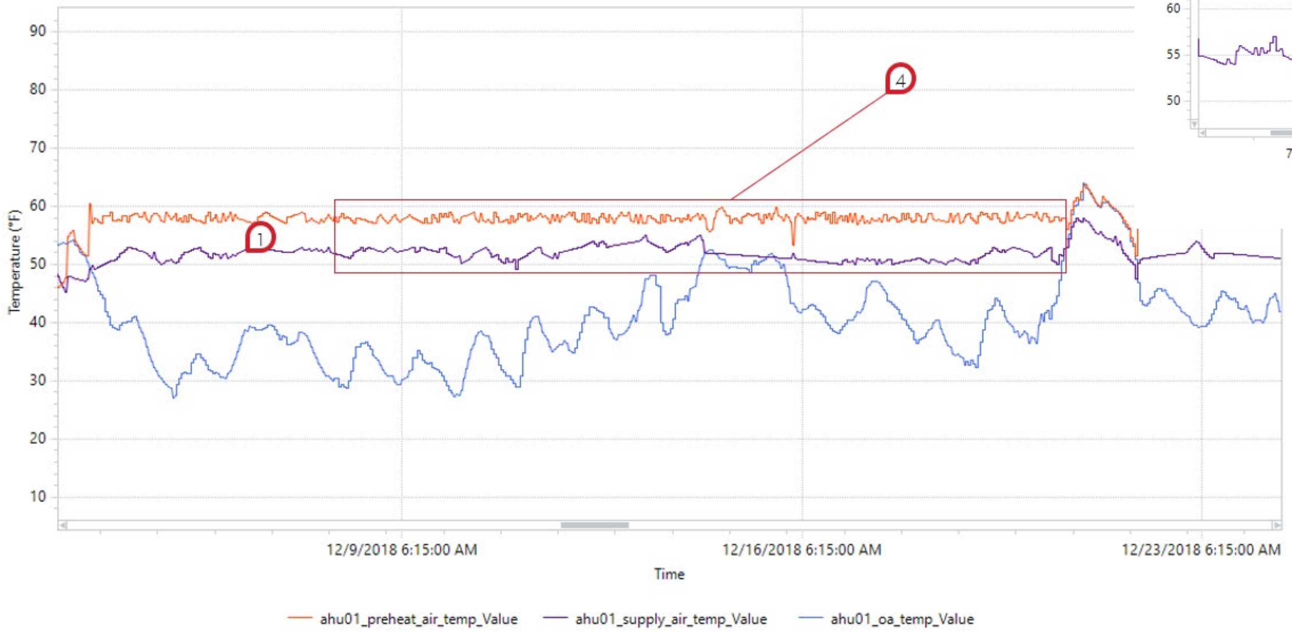




| TEST DATA | DESIGN | ACTUAL |
|---|---|---|
| TOTAL CFM *(Sum of VAV's)* | 15,190 | 15,498 |
| RETURN AIR CFM | 11,990 | 12,324 |
| OUTSIDE AIR CFM | 3,200 | 3,174 |
| TOTAL STATIC PRESSURE" | 4.37" | 4.42" |
| EXTERNAL STATIC PRESSURE" | 3.00" | 4.10" |

# Lessons Learned: Energy Recovery

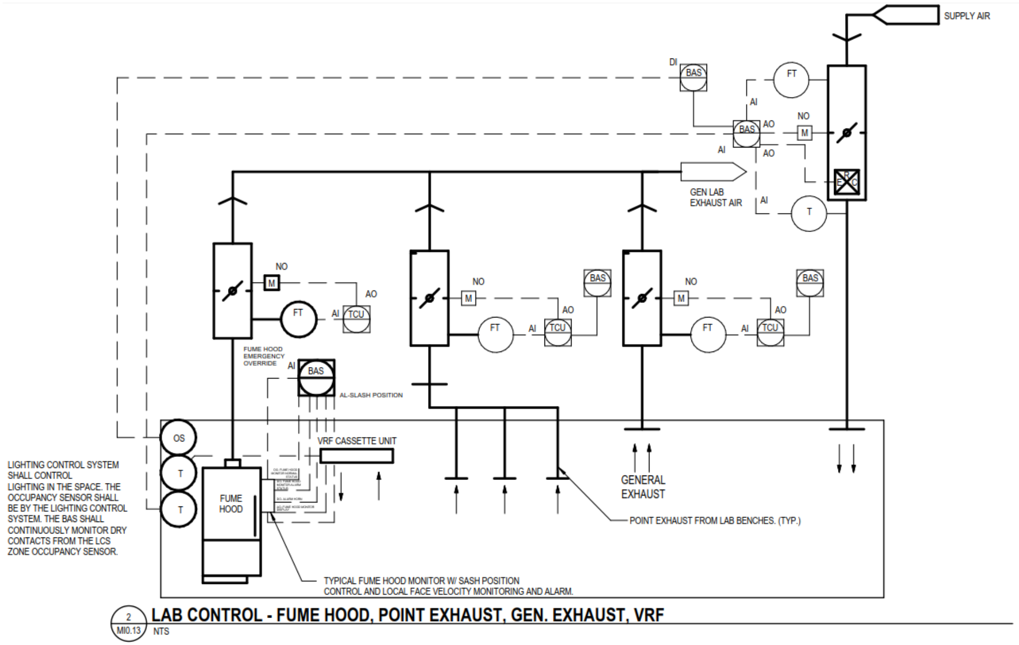
- Simultaneous Heating/Cooling



# Lessons Learned: HVAC Strategies

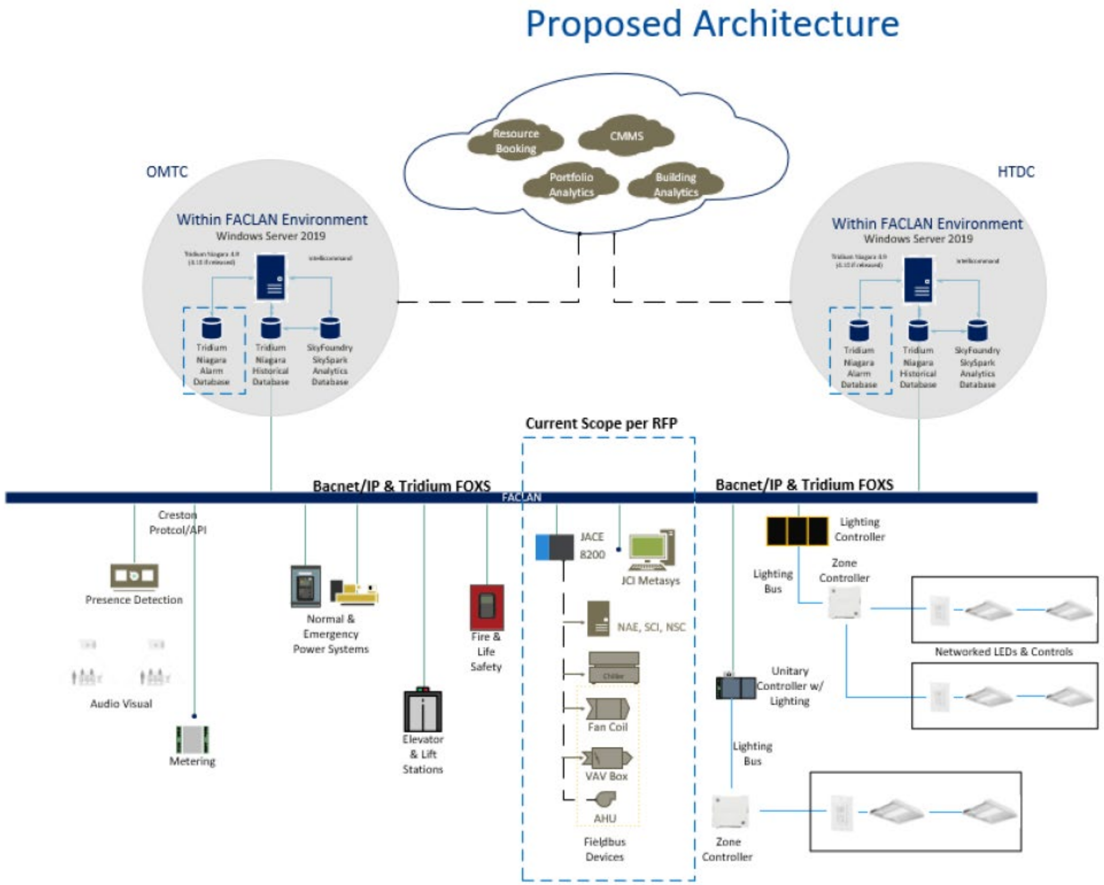
- Decouple
- Electrification




Standby Power Mode

7. Under standby utility power mode the supply fans shall be started and operated using the same sequence described above, up to a maximum of 25% of maximum AHU airflow – total of 5000 cfm (adj.). Airflow and fan speed control duct static pressure alarms shall be over ridden/suspended when operating under standby power mode.

# Future of Monitoring-Based Commissioning



# Questions?
# Thank You!

Michael J. Dooley, PE, CCP, CEM, LEED AP