BCxA Building Commissioning Association

All-electric and Net Zero Design: Skills and Abilities for Today's CxP

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Course Description

1. Session participants will be able to evaluate complex net-zero HVAC designs and intricate systems' controls to systematically identify common engineering shortcomings and operational risks for Owners and Engineers of Record (EORs).
2. Session participants will be able to identify specific energy conservation measures, control system enhancements, and operational optimizations across all phases of the building commissioning (Cx) process on complex projects.
3. Session participants will be able to conduct high-impact, Owner-advantageous design reviews on complex projects to provide actionable feedback to Engineers of Record (EORs) and align system designs with the Owner's Project Requirements (OPR).
4. Apply tested communication strategies to enhance interdisciplinary collaboration and integrate a reluctant Engineer of Record (EOR) as a partner into the commissioning workflow.

Where We Are vs. Where We Need to Go

Transforming the commissioning profession from late-stage friction into early design leadership.

CURRENT STATUS QUO

The Commodity Reality

- **Adversarial Posturing: Friction and defensiveness between CxPs and Engineers of Record.**
- **Late CD Reviews: Catching sequence flaws when redesign costs are highest.**
- **Checklist Mentality: Verifying schedules in isolation VS as integrated systems with consideration of dynamic controls.**
- **Sampling Guesswork: Testing 20% of terminal units and hoping for the best.**

THE PATH FORWARD

The High-Performance Provider

- **Partnering Mindset: Aligning privately with EORs to eliminate conflict and reduce RFIs.**
- **SD/DD Upstream Peer Review: Influencing architecture and MEP approach before concrete and steel are ordered.**
- **Controls Mastery: Guideline 36 prowess, assuming the role of the Controls Authority.**
- **High-Performance Commissioning Methods: Virtual FPTs, Automated FPTs, and Connected Commissioning.**

The Core Mindset Shift: You are not external compliance auditor. You are an indispensable design and construction ally. EMPOWERMENT

The High-Performance Provider

Empowering real engineering impact, owner trust, and verified outcomes.

OVERVIEW

PILLAR 01

Partnering Mindset

- Soft Skills
- Mindset

PILLAR 02

Technical Caliber

- Owner-Advantageous Design Reviews
- ASHRAE Guideline 36
- High-Performance Submittal Reviews

PILLAR 03

Commissioning Innovation

- Simulated FPTs (Bench Testing)
- Automated FPTs
- Connected Cx (Real-time Trends & AFDD)
- Commissioning Platforms

Partnering Mindset

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Partnering Over Posturing with the EOR

SOFT SKILLS

1. Pre-Empt Conflict Early

Direct communication before owner meetings prevents defensive posturing.

2. Share the Credit

Elevate the engineer in front of architects to build lasting interdisciplinary trust.

3. Teamwork Responding to Roadblocks

Co-author RFI responses, peer-review calcs, and data sharing to ensure alignment, and minimize contractor confusion, and need for Owner decision-making.



PARTNERING MINDSET

"When an engineer trusts that you won't blindside them, resistance disappears."

Commissioning succeeds through alliances, not audits.

Moving from Commodity to High-Impact

MINDSET

The Commodity Pitfall

Late Engagement: Reviewing only during CD phase.

Checklist Mentality: Generic "Conforms to Drawings" stamps.

Adversarial Posturing: Antagonizing design engineers and contractors.

Superficial Sampling: Testing under 20% of terminal equipment.

The High-Performance Standard

Upstream Integration: Influencing SD/DD when change cost is lowest.

Deep Technical Rigor: Line-by-line sequence and hydronic audits.

Collaborative Ally: Solving issues directly to eliminate field RFIs.

100% Automated FPT: Exhaustive testing with repeatable scripts.

Core Premise: Technical brilliance fails without emotional intelligence. High performance requires both.

Technical Precision

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Owner-Advantageous Design Reviews

TECHNICAL CALIBER

HIGH-PERFORMANCE DESIGNS *Require* HIGH-PERFORMANCE DESIGN REVIEWS

Educate Owners	Educate Engineers-of-Record	Educate Yourself

Commodity Commissioning

Reactive Administrative Exercise: Executed late in Construction Documents (CD) when drawing changes are rigid and expensive.

Skims control sequences, focuses primarily on equipment schedules and general code compliance, deferring critical integration flaws into field testing.

High-Value Commissioning

Proactive Operational Safeguard: Initiated during early Design (Schematic or Design Development).

Focuses on dynamic performance, full sequence of operations, control loop stability, cross-trade integration, and long-term physical maintainability.

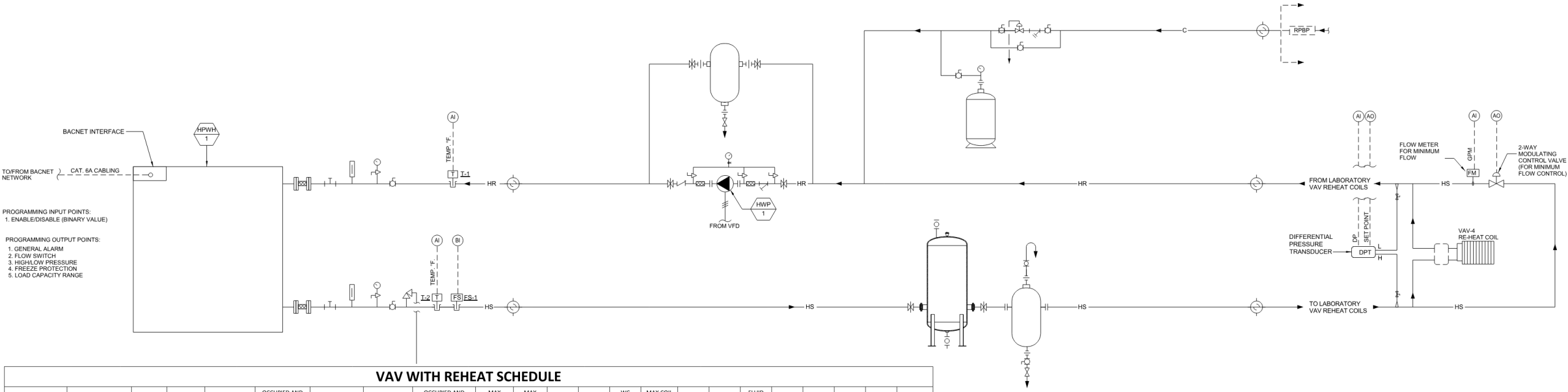
Design Reviews

TECHNICAL CALIBER

Review Timing	COMMODITY APPROACH Delayed to late CD when drawing revisions trigger costly change orders.	HIGH-VALUE COMMISSIONING **Initiated during SD/DD when cost of modification is negligible.**
Technical Scope	COMMODITY APPROACH Checks schedule capacities while skipping control sequence logic.	HIGH-VALUE COMMISSIONING **Audits control loops, failure states, reset algorithms, and clearances.**
Comment Quality	COMMODITY APPROACH Generic remarks ("verify sizing") lacking clear engineering direction.	HIGH-VALUE COMMISSIONING **Defines the specific failure risk paired with an actionable solution.**

Design Reviews

TECHNICAL CALIBER



VAV WITH REHEAT SCHEDULE

TAG	MANUFACTURER	MODEL	UNIT SIZE	ASSOCIATED TRACKING VALVE	OCCUPIED AND UNOCCUPIED MAX COOLING CFM	UNOCCUPIED MIN CFM	OCCUPIED MIN CFM	OCCUPIED AND UNOCCUPIED MAX HEATING CFM	MAX DISCHARGE NC	MAX RADIATED NC	EAT (°F)	LAT (°F)	WC CAPACITY (MBH)	MAX COIL APD (IN. W.G.)	EWT (°F)	LWT (°F)	FLUID FLOW (GPM)	FLUID PD (FT. W.G.)	ROWS	FPI	CONTROL VALVE	NOTES
VAV-1	PRICE	SDV5	12	EAV-1	400	80	80	-	<20	13	55	55	-	-	-	-	-	-	-	-	-	1
VAV-2	PRICE	SDV5	12	EAV-2	430	430	430	430	<20	13	55	95	19.1	0.06	120	100	2.0	0.34	3	10	2-WAY	2
VAV-3	PRICE	SDV5	06	EAV-3	125	25	25	63	<20	-	55	95	3.3	0.03	120	113	1.1	0.22	2	10	2-WAY	
VAV-4	PRICE	SDV5	14	EAV-4	650	130	130	325	<20	14	55	95	14.1	0.05	120	111	3.3	0.53	2	10	2-WAY	
VAV-5	PRICE	SDV5	06	EAV-4	125	25	25	63	<20	-	55	95	2.9	0.03	120	114	1.0	0.20	2	10	2-WAY	
VAV-6	PRICE	SDV5	08	EAV-4	170	34	34	85	<20	-	55	95	3.8	0.03	120	112	1.0	0.26	2	10	2-WAY	

NOTES:
1. COOLING ONLY (NO REHEAT COIL).
2. THIS IS A CONSTANT VOLUME SUPPLY TERMINAL UNIT.

PUMP SCHEDULE

TAG	MANUFACTURER	MODEL NUMBER	SERVICE	GPM	TOTAL DYN. HEAD (FT)	EFF. (%)	MOTOR						OPERATING WEIGHT (LBS)	NOTES
							RPM	BHP	HP	VOLTS	PH	HZ		
HWP-1	BELL & GOSSETT	Series e-80 1.5x1.5x9.5B	HEATING HOT WATER LOOP	43	70	48.1	1,800	1.6	3	460	3	60	180	1, 2, 3

NOTES:
1. MOTOR TO BE INVERTER-DUTY RATED FOR USE WITH VFD.
2. PROVIDE WITH LARGEST IIMPELLER AVAILABLE.
3. SEE PIPING DIAGRAMS FOR ADDITIONAL PUMP AND PIPING APPURTENANCES.

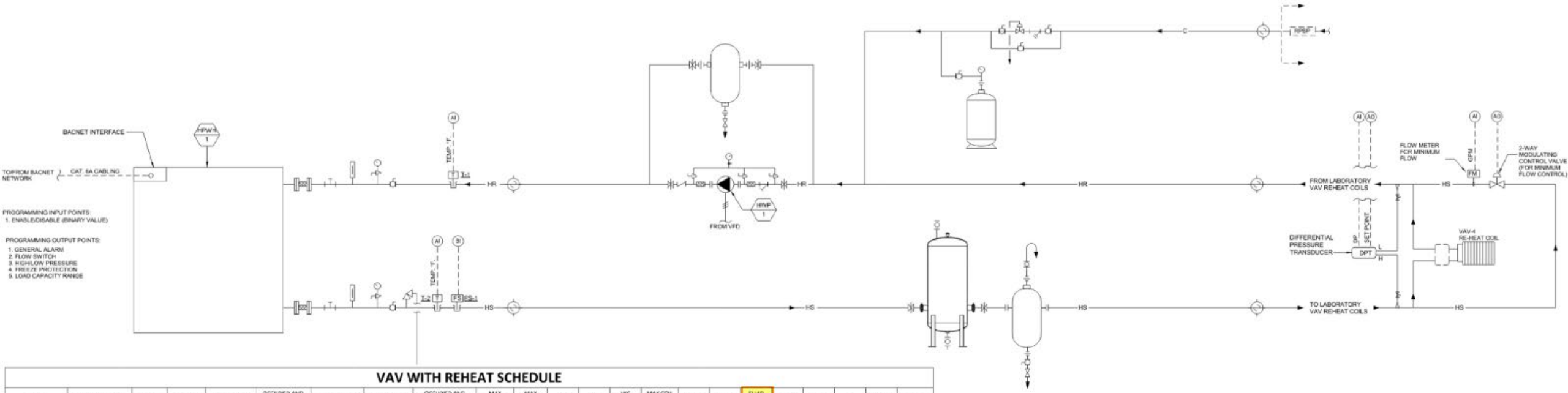
AIR-WATER HEAT PUMP SCHEDULE

TAG	MANUFACTURER	MODEL	NOMINAL CAPACITY (TONS)	# COMPRESSORS	COMPRESSOR TYPE	REFRIGERANT TYPE	EFFICIENCY	AMBIENT OAT (°F)	SYSTEM SIDE					ELECTRICAL					WET WEIGHT (LBS)	NOTES
							COP		FLUID	EWT (°F)	LWT (°F)	HEATING FLOW (GPM)	PD (FT.)	VOLTS	PH.	HZ	MCA	MOCP		
HPWH-1	LG	KCHH020LDGC	18.5	2	SCROLL	R32	2.60	28	WATER	120	140	52	3.0	460	3	60	50.9	60	1,150	1, 2

NOTES:
1 DUAL COMPRESSORS AND COOLING CIRUITS.
2 PROVIDE WITH BACNET INTERFACE.

Design Reviews

TECHNICAL CALIBER



VAV WITH REHEAT SCHEDULE

TAG	MANUFACTURER	MODEL	UNIT SIZE	ASSOCIATED TRACKING VALVE	OCCUPIED AND UNOCCUPIED MAX COOLING CFM	UNOCCUPIED MIN CFM	OCCUPIED MIN CFM	OCCUPIED AND UNOCCUPIED MAX HEATING CFM	MAX DISCHARGE NC	MAX RADIATED NC	EAT (°F)	LAT (°F)	WC CAPACITY (MBH)	MAX COIL APD (IN. W.G.)	EWT (°F)	LWT (°F)	FLUID FLOW (GPM)	FLUID PD (FT. W.G.)	ROWS	FPI	CONTROL VALVE	NOTES
VAV-1	PRICE	SDVS	12	EAV-1	400	80	80	-	<20	13	55	55	-	-	-	-	-	-	-	-	-	1
VAV-2	PRICE	SDVS	12	EAV-2	430	430	430	430	<20	13	55	95	19.1	0.06	120	100	2.0	0.34	3	10	2-WAY	2
VAV-3	PRICE	SDVS	06	EAV-3	125	25	25	63	<20	-	55	95	3.3	0.03	120	113	1.1	0.22	2	10	2-WAY	
VAV-4	PRICE	SDVS	14	EAV-4	650	130	130	325	<20	14	55	95	14.1	0.05	120	111	3.3	0.53	2	10	2-WAY	
VAV-5	PRICE	SDVS	06	EAV-4	125	25	25	63	<20	-	55	95	2.9	0.03	120	114	1.0	0.20	2	10	2-WAY	
VAV-6	PRICE	SDVS	08	EAV-4	170	34	34	85	<20	-	55	95	3.8	0.03	120	112	1.0	0.26	2	10	2-WAY	

NOTES:
1. COOLING ONLY (NO REHEAT COIL).
2. THIS IS A CONSTANT VOLUME SUPPLY TERMINAL UNIT.

Sum = 8.4 GPM

PUMP SCHEDULE

TAG	MANUFACTURER	MODEL NUMBER	SERVICE	GPM	TOTAL DYN. HEAD (FT)	EFF. (%)	MOTOR RPM	MOTOR BHP	MOTOR HP	MOTOR VOLTS	MOTOR PH	MOTOR HZ	OPERATING WEIGHT (LBS)	NOTES
HWP-1	BELL & GOSSETT	Series e-80 1.5x1.5x9.5B	HEATING HOT WATER LOOP	43	70	48.1	1,800	1.6	3	460	3	60	180	1, 2, 3

NOTES:
1. MOTOR TO BE INVERTER-DUTY RATED FOR USE WITH VFD.
2. PROVIDE WITH LARGEST IMPELLER AVAILABLE.
3. SEE PIPING DIAGRAMS FOR ADDITIONAL PUMP AND PIPING APPURTENANCES.

High.

Does not match ASHP or VAV GPM.

AIR-WATER HEAT PUMP SCHEDULE

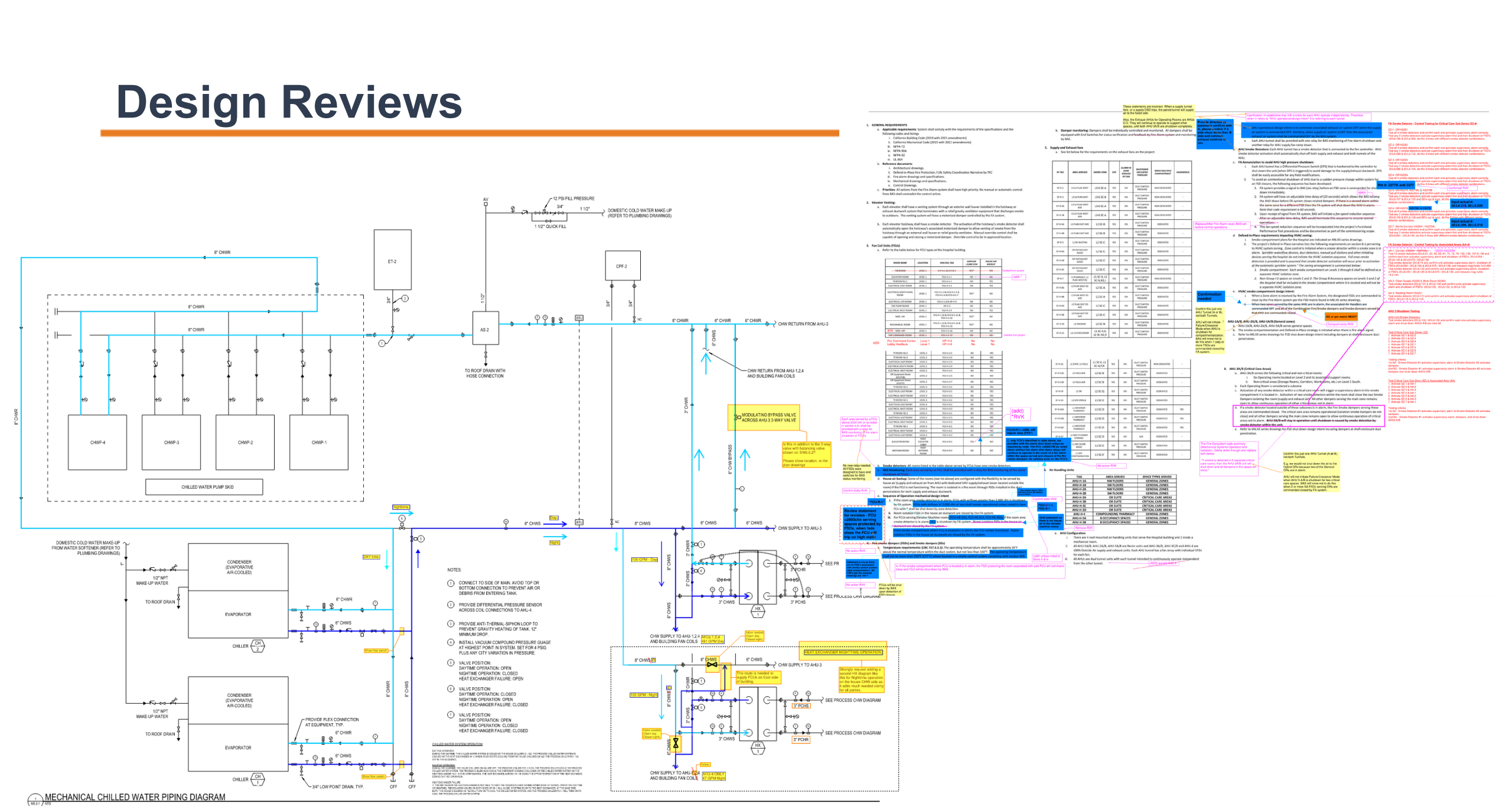
TAG	MANUFACTURER	MODEL	NOMINAL CAPACITY (TONS)	# COMPRESSORS	COMPRESSOR TYPE	REFRIGERANT TYPE	EFFICIENCY COP	AMBIENT OAT (°F)	SYSTEM SIDE FLUID	SYSTEM SIDE EWT (°F)	SYSTEM SIDE LWT (°F)	SYSTEM SIDE HEATING FLOW (GPM)	SYSTEM SIDE PD (FT.)	ELECTRICAL VOLTS	ELECTRICAL PH.	ELECTRICAL HZ	ELECTRICAL MCA	ELECTRICAL MOCP	WET WEIGHT (LBS)	NOTES
HPWH-1	LG	KCHH020LDGC	18.5	2	SCROLL	R32	2.60	28	WATER	120	140	52	3.0	460	3	60	50.9	60	1,150	1, 2

NOTES:
1 DUAL COMPRESSORS AND COOLING CIRUITS.
2 PROVIDE WITH BACNET INTERFACE.

Correct to match VAV Reheat Schedule.

ASHP is massively oversized.

Design Reviews



1 MECHANICAL CHILLED WATER PIPING DIAGRAM
M5.01 NTS

ASHRAE Guideline 36 (VAVRH)

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ASHRAE Guideline 36

TECHNICAL CALIBER

- **Proven Field Performance:** NREL and LBNL field trials demonstrate that **fully commissioned** Guideline 36 VAV-reheat control sequences achieve substantial efficiency gains:
  - **HHW Energy Savings:** Reduced up to 45% due to lower minimum airflow setpoints and elimination of simultaneous heating/cooling.
  - **CHW Energy Savings**: Reduces chiller plant energy consumption 15 – 25%.
  - **Fan Energy Savings:** Reduced 25–35% via Trim-and-Respond duct static pressure reset.
  - **Overcooling Prevention:** 70% reduction in occupant comfort complaints regarding cold drafts.

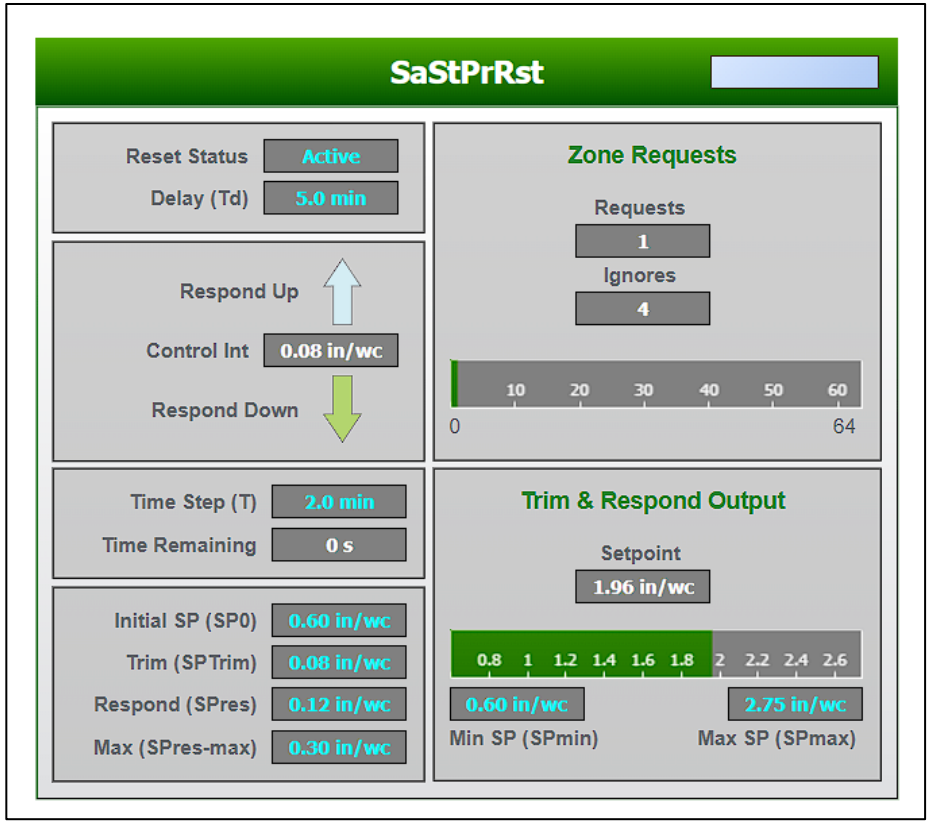
PARAMETER	DESCRIPTION	INITIAL VALUE
SP_0	INITIAL SET POINT	AHU-1A [TBD during TAB work] AHU-1B [TBD during TAB work] AHU-2A [TBD during TAB work] AHU-2B [TBD during TAB work] AHU-5A [TBD during TAB work] AHU-5B [TBD during TAB work]
SP_{MIN}	MINIMUM SET POINT	AHU-1A [0.25" WC] AHU-1B [0.25" WC] AHU-2A [0.25" WC] AHU-2B [0.25" WC] AHU-5A [0.25" WC] AHU-5B [0.25" WC]
SP_{MAX}	MAXIMUM SET POINT	[3.0" WC]
T_D	DELAY TIMER	[10 MINUTES]
T	TIME STEP	[2 MINUTES]
I	NUMBER OF IGNORED REQUESTS	[2]
R	NUMBER OF REQUESTS FROM TERMINAL ZONES	ZONE STATIC PRESSURE RESET REQUESTS
SP_{TRIM}	TRIM AMOUNT	[-0.05" WC]
SP_{RES}	RESPOND AMOUNT	[+0.06" WC]
$SP_{RES-MAX}$	MAXIMUM RESPONSE PER TIME INTERVAL	[+0.13" WC]

ASHRAE Guideline 36

TECHNICAL CALIBER

Advanced Implementation Tips & Common Designer Errors in VAV-Reheat Systems

Issue / Shortcoming	Recommended Solution
Vmin vs Vheating	Correct Dual-max Implementation
Ignores for Rogue Zones	Use Rogue Zone Counters
MS/TP Bus Overload	Reduce Polling Rates. BACnet/IP
Poor Low-Turndown Veff (stratification)	Limit DAT to +20F (15F better)
Modulation of Damper and Valve Together	Cascading Control Loops
One Alarm Level	4 Levels of Alarms + Suppression SOOs
Hunting Setpoints	Trim, Respond, and Time Step must be customized. Respond > Trim.
Poor Operator Controls	Intuitive Interfaces
Critical Zones	Request Importance Multipliers
Poor Warmup/Cooldown Performance	Decouple T&R; Use GL36 Optimum Start and Warmup and Cooldown Modes



ASHRAE Guideline 36

TECHNICAL CALIBER

Low-flow myths for Commissioning Providers to Disperse

Actual Transducer Accuracy

Cataloged box limits are overly conservative. **Modern DDC transducers accurately control down to 0.005 in. w.g. velocity pressure**, far below manufacturer default published thresholds.

Time-Averaged Ventilation (TAV) [ASHRAE 62.1]

When flow falls below controllable minimums, TAV opens the VAV box damper from closed to the controllable minimum for 90-seconds, to maintain 15-min average outdoor air rates.

Field Energy Reductions

Implementation of TAV sequences on conservative systems delivers proven savings: 20% fan energy, 23% cooling energy, and 41% heating reheat energy reduction.

Submittal Reviews

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Submittal Reviews

TECHNICAL CALIBER

- Poll Question 1
- >What should a CxP be focused on reviewing, or looking for, in an MEP submittal?

- Poll Question 2
- >What should a CxP not be spending time on reviewing in an MEP submittal?

- Poll Question 3
- >What is your overall mindset and goals when reviewing an MEP submittal?

High-Performance Submittal Reviews

TECHNICAL CALIBER

Review Approach Comparison

"Good Reviews Take Time"

Review Area	Exceptional CxP	Everyday / Rubber Stamp
Primary Goal	Dynamic operation & lifecycle performance	Superficial specification check
Controls Assurance	Audits point tables, BAS hardware, & Sequences	Defers entirely to BAS vendor
Spatial Access	Verifies coil pulls, belt replacements, lubing, & strainer blowdown	Overlooks physical clearances
Pressure Drop Calculations	Filter Loading, OA tunnel sized for full AHU CFM	Submittal ESP and TSP matches the equipment schedule
Measurement Scales	Understands Grade B Gauges (ASME B40.100) & Full-Scale vs Reading Error % Accuracy	Not considered. Assumes the vendor took this into consideration.
Comment Quality	Specific, cross-coordinated, actionable solutions	Generic "Conforms to contract documents" stamp
Review Timing	Concurrent or prior to EOR review	Uncoordinated or after EOR approval

Key Takeaway: Reviewing against the project specs or metrics in the OPR is not enough. We should provide our own detailed peer-review as **holistic Owner-advocates**, **Partners with EORs**, and **the primary auditor of the controls**.

Core Technical Review Focus

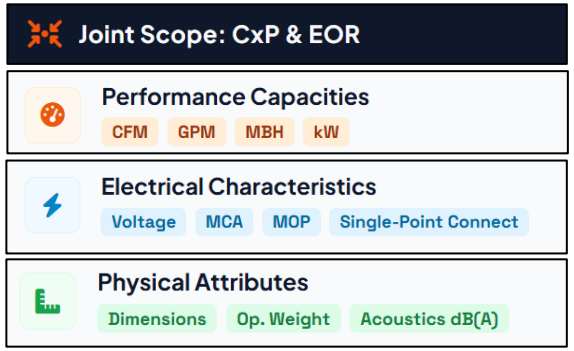
"Proactive, Technical-Advocacy"

Operability & Physical Access
Ensure clearance for tube pulling, filter replacement, motor lubing, and ladder access.

Controls *Interrogation*
Audits factory controller protocols (BACnet MS/TP vs IP), point maps, sensor placement, and line-by-line Sequence of Operation review

Field Testability & TAB Readiness
Verifies thermal wells, PT ports, and straight-run requirements for flow meters.

Lifecycle & Energy Advocacy
Protects part-load efficiency, acoustic isolation, and long-term equipment life.



Automated Functional Performance Testing

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Automated Functional Performance Testing

COMMISSIONING INNOVATION

- Poll Question

Given a project with 250 terminal units (VAV boxes, FCUs,etc), what sampling percentage do you typically implement on YOUR projects?

1. 5-10%
2. 10-15%
3. 15-25%
4. 25-35%
5. 35-50%
6. 50-80%
7. 80-99 %
8. 100% (no sampling, test every unit)



Automated Functional Performance Testing

COMMISSIONING INNOVATION

- Remote Implementation
  - Any Day. Any Time of Day. Scheduled.
- Test Every Terminal Unit (i.e. NO sampling)
- Automated Results
- Full Load Testing
- Repeatability
  - The exact same test, every time.
- Cost Effective
  - Marginal Cost for each additional test.



Automated Functional Performance Testing

COMMISSIONING INNOVATION

- Comparison of Manual FPTs vs Automated FPTs – **Sampling**
- 250 Terminal Units (VAVs and FCUs)
- **20% Sampling** [**50**].
  - 10% Allowable Failure [5] -> 40% Backcheck [2] +
    10% New Sample [20]. 50 + 2 + 20 = **72 Units Tested.<250 Units Pass**

	Traditional "Manual"	Automated
Testing Days	2	1
Time of Testing	Working Hours	Anytime
Hours Spent in the Field	~12	2 (Equipment Install)
Full Load Testing	No	Yes
Cost of Testing 1 more box	$$$	~$0 (1 hour)
Cost of Testing 20 more boxes	$$ * 20 boxes [Linear Scale]	~$0 (2 hours) [No Relationship]

Automated Functional Performance Testing

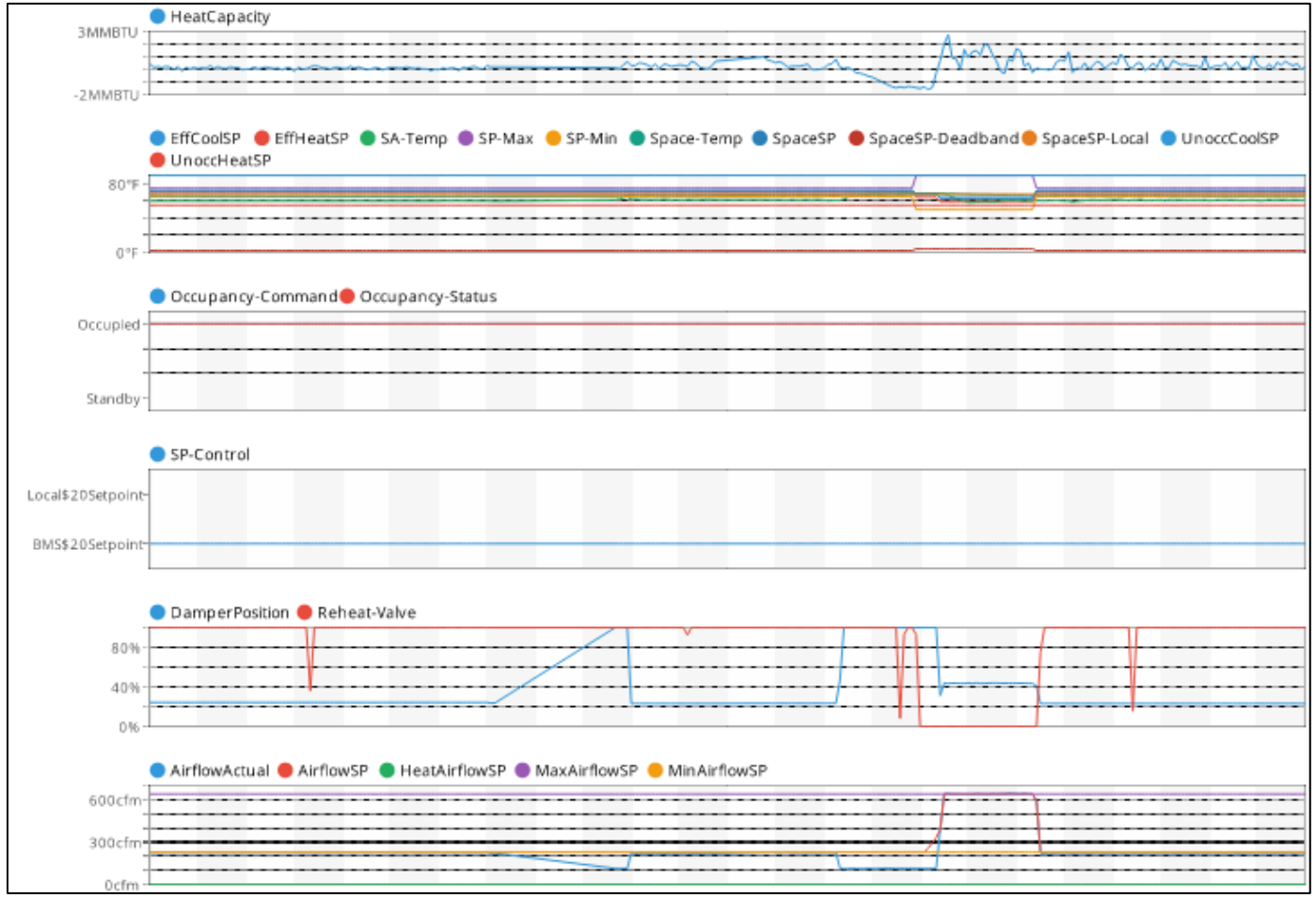
COMMISSIONING INNOVATION

- Comparison of Manual FPTs vs Automated FPTs – **No Sampling**
- 250 Terminal Units (VAVs and FCUs)
- **100% Sampling**. 100% Backcheck.
  - 250 + 250 = **500 Units Tested**. **250 Units Pass**.

	Traditional "Manual"	Automated
Testing Days	10	2
Time of Testing	Working Hours	Anytime
Hours Spent in the Field	75	2, (Equipment Install) 2, Inspection
Full Load Testing	No	Yes
Cost of Testing Additional 50 boxes	1 day, ~7 hours $$$$	(2 hours)
Records	Manual. Human error.	Automatic.

Live Trend Data and AFDD

COMMISSIONING INNOVATION



Document Existing Conditions (Assumes HVAC in Occupied Mode) [8:00PM - 8:20PM]

Functional Questions

1	Does Occupancy = Occupied ? (if no, test results for this mode are invalid)	Pass
2	Occupancy	true
3	Is Space-Temp < Space-SP + 1degF ? (i.e., is steady state comfort control being provided?)	Fail
4	Space-Temp	55.9 °F
5	Space-SP	0 °F

Occupied No-Load Mode [8:20PM - 8:50PM]

Override Space Setpoints to result in a no-load condition (ie, SpaceTemp squarely within setpoints)

Override: Space-SP = current Space-Temp + 2degF

Functional Questions After 20 min... [8:40PM]

6	Does Occupancy = Occupied ? (if no, test results for this mode are invalid)	Pass
7	Occupancy	true
8	Is current Space-Temp < Space-SP ? (if no, test results for this mode are invalid)	Pass
9	Space-Temp	56.5 °F
10	Space-SP	58.3 °F
11	Does SF-Command = On ?	Pass
12	SF-Command	true
13	Does SF-Status = On ?	Pass
14	SF-Status	true
15	Does CHW-Valve = 0% ?	Pass
16	CHW-Valve	0 %

Occupied Cooling Mode [8:50PM - 9:50PM]

Override: Override Space Setpoints to result in a cooling condition (ie, override Space Setpoints a few degrees below current Space Temperature)

Override: Space-SP = current Space-Temp - 5degF

Functional Questions After 20 min... [9:10PM]

17	Does Occupancy = Occupied ? (if no, test results for this mode are invalid)	Pass
18	Occupancy	true
19	Is current Space-Temp > Space-SP ? (if no, test results for this mode are invalid)	Pass
20	Space-Temp	56.3 °F
21	Space-SP	51.5 °F
22	Does SF-Command = On ?	Pass

Conclusion & Key Takeaways

PILLAR 01

Partnering Mindset

Allied Posture: Pre-empt friction before owner meetings.

Shared Credit: Elevate engineers to build trust.

Co-Authored RFIs: Solve roadblocks collaboratively.

PILLAR 02

Technical Caliber

Deep Design Reviews: Interrogate SD/DD designs early.

Controls Mastery: Enforce Guideline 36 sequences.

Elevated Submittals: Audit controls, energy, and access.

PILLAR 03

Commissioning Innovation

100% Coverage: Eliminate sampling via automated FPTs.

Repeatable Tests: Execute identical full-load scripts.

Connected Cx: Leverage real-time trend analytics.

High-Performance Designs Require the High-Performance Commissioning Provider

Questions?

Partnering Mindset

Technical Caliber

Commissioning Innovation



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CONSULTING ENGINEERS