Investigation and Testing in EBCx

Investigation and Testing: Purpose

- To Determine How The Building Is Actually Operating and Compare It to The Owner's Current Needs
- Typically Focuses On Energy and Indoor Environmental Quality
- Goal Is To Establish The Current Baseline and Identify Improvements

Roles and Responsibilities: EBCx Investigation & Testing

- EBCX Agent is the leader
- The best situation is if the Owner's staff is capable and available to conduct investigation and correction under the guidance of the EBCX Agent
- Who will do the actual testing; the owner, EBCX Agent, manufacturers representatives, subcontractors?

Process Overview

- EBCx opportunities are uncovered during the Investigation Process via:
  - Interviewing the Owner's staff
  - Visual inspections during walkthroughs
  - Current air/water flows vs. current needs (TAB)
  - BAS Graphic & Trend Log reviews
  - Functional testing and improved sequences

Interviewing the Owner's Staff

- The Owner's staff often knows many operational improvements which could be made
- Operators sometimes don't understand why things are the way the are because there has been poor documentation of the Basis of Design and subsequent changes
- They often have not been given the resources to make changes or to be adequately trained

Walkthroughs – Information Gathering

- Gather information from BAS (graphics, trends)
- Look for failed end-devices (broken actuators, stuck dampers and valves)
- Look at condition of OA dampers and filtration
- Note position of hydronic balancing valves, operating temps and pressures, and VFD speeds
- Be cognizant of pressurization between spaces
- Make note of sensor locations
- Look above ceilings (primary air in the plenum – torn ductwork, VAVs with too much primary air)

Role of TAB During EBCx Investigation

- Buildings cannot be controlled unless the fluid flows are the right quantities in the right places
- TAB and controls are integral
- Most building systems are never checked again after initial TAB yet conditions have changed
- Initial TAB may not have occurred
- Improperly balanced systems are the source of comfort and IAQ problems and wasted energy
- Typically OA ventilation quantities are checked

Scope of TAB During EBCx Investigation

- Major pieces of equipment are checked (AHU's, exhaust fans, pumps, chillers, boilers)
- Building pressurization, static pressures, differential pressures, CO_2 levels, lighting levels are checked
- Sensors and instrumentation are recalibrated
- OA sensors, flow control sensors, flow sensors (water, AHU, and VAV boxes) are a big focus

The Role of Building Automation Systems in EBCX

- The BAS is an important Cx tool
- The BAS is a window to reality
- The BAS can be used to investigate, diagnose and solve building operations
- Many EBCX Opportunities are related to Cx of the BAS Itself

Evaluating the BAS

- Initially assess the extent of the BAS and it's functionality
  - Is the front end functioning?
  - What is the system type and architecture?
  - What problems does the owner have when using the BAS?

Gathering Information from the BAS

- Get familiar with the systems/schematics
- Print the graphics – these screenshots usually show most of the setpoints and actuals
- Print time-of-day schedules as a group
- Print an all-points log to see what's connected to the BAS
- Review alarm report
- Print a disabled log

BAS Investigation – Multiple Truths

- Compare drawings/sequences with actual programming and setpoints
  - Check setpoints against actuals
  - Check program against sequences
  - Review reset schedules
  - Evaluate static and differential pressures
  - Evaluate deadbands
  - Identify energy specific algorithms

Common Roadblocks with BAS Investigation Process

- Lack of enabled trend logs
- Inability to handle necessary communications to effectively use trend logs
- Systems which have been modified but the changes have not been documented
- Unitary devices which do not communicate with the BAS

Common Problems with the BAS

- Systems designed for comfort control and not energy management
- Control systems which were never commissioned!
- Control systems which have not been maintained
- Lack of points and/or meters
- Legacy systems which have minimal functionality
- Front end user interface with outdated software, poor communications capability, running on a PC which is loaded with malware

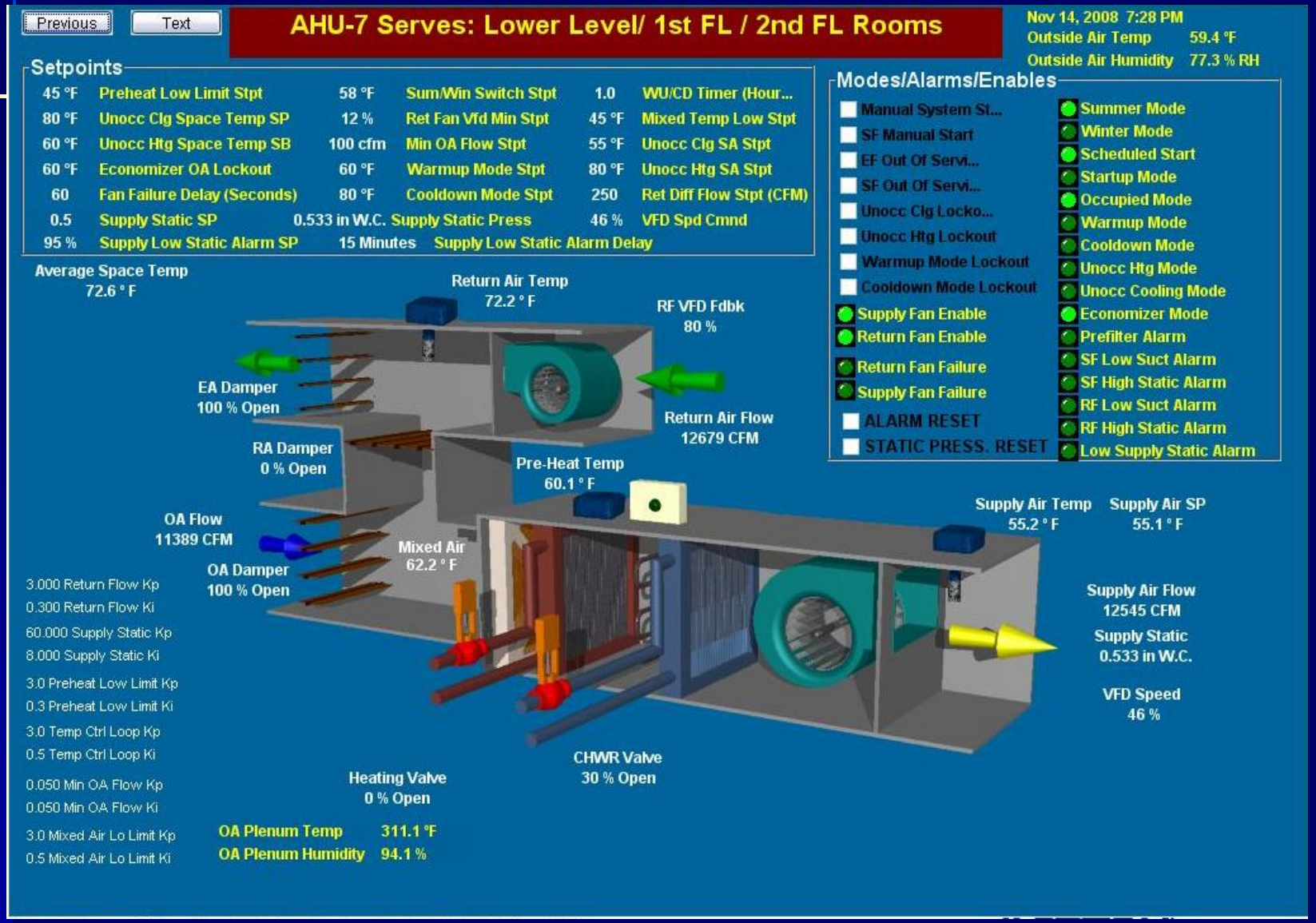
What makes a good BAS graphic?

- Links to related graphics, sequences of operation, schedules, and “home”.
- Set points versus actuals adjacent to each other
- Outside air conditions (temp/humidity/enthalpy) should be shown in the same location on all screens
- Indication of run status; on/off/manual
- Lead/Lag status; heating/cooling/economizer

What makes a good BAS graphic?

- Sensor locations on graphic = sensor location in reality
- Flow arrows on piping & ductwork
- Points in manual override and/or alarm should be shown in red
- BACnet points (read-only) shown separately

Example: BAS Graphic



Trend Logs

- What are trend logs?
- What to look for when searching for opportunities?
- How to use trend logs

Trend Logs

- What are they?
  - Time interval stamped data points of actual conditions as read and recorded by the BAS
  - Usually presented as Comma-Separated Values, Excel, or Graphs

Example: Trend Log Data

AHU-1		Cooling Valve % Open	Supply Air Flow (cfm)	Heating Valve % Open	Humidity Valve (mA)	Pre-Heat Temp (F)	SAF Status	Supply Air Temp Setpoint (F)	Supply Air Temp (F)	Supply Fan VSD Output (0-10 V)	VSD Freq. (Hz)	Outside Air Temp (F)
Date	**Time**	**A01CCO**	**A01CFM**	**A01HCO**	**A01HUV**	**A01PHT**	**A01SAF**	**A01SAS**	**A01SAT**	**A01SVD**	**A01SVO**	**OAT**
5/8/2011	0:00:00	0	3107.2	100	4	76.3	ON	96.2	76.5	4	39.6	59.35
5/8/2011	0:15:00	0	3107.2	100	4	76.3	ON	98	77.5	4	39.6	59.2
5/8/2011	0:30:00	0	3075.3	100	4	76.3	ON	99.8	77.3	3.9	38.6	58.05
5/8/2011	0:45:00	0	3083.3	100	4	74.3	ON	101.5	73.3	4	39.6	58.4
5/8/2011	1:00:00	0	3075.3	100	4	76.3	ON	103.1	77.4	4	40.1	58.95
5/8/2011	1:15:00	0	3107.2	100	4	78.3	ON	104.7	78.4	4	39.6	58.85
5/8/2011	1:30:00	0	3067.3	100	4	78.3	ON	106.3	77.9	4	40	58.7
5/8/2011	1:45:00	0	3123.1	100	4	78.3	ON	107.8	77.3	4	39.5	58.2
5/8/2011	2:00:00	0	3083.3	100	4	78.3	ON	109.3	77.6	4	39.6	58.4
5/8/2011	2:15:00	0	3083.3	100	4	74.3	ON	110	74.4	3.9	39.3	57.9
5/8/2011	2:30:00	0	3075.3	100	4	74.3	ON	110	73.5	4	39.8	57.45
5/8/2011	2:45:00	0	3059.3	100	4	76.3	ON	110	77.8	4	39.9	59.35
5/8/2011	3:00:00	0	3083.3	100	4	78.3	ON	110	78.8	4	39.6	59.05
5/8/2011	3:15:00	0	3083.3	100	4	78.3	ON	110	78.8	4	39.6	58.7
5/8/2011	3:30:00	0	3099.2	100	4	78.3	ON	110	78.3	3.9	38.9	58.35
5/8/2011	3:45:00	0	3139.1	100	4	78.3	ON	110	78.6	3.9	39.3	59.2
5/8/2011	4:00:00	0	3099.2	100	4	74.3	ON	110	74.6	4	39.8	57.7
5/8/2011	4:15:00	0	3131.1	100	4	72.3	ON	110	71.8	3.9	38.7	57.95
5/8/2011	4:30:00	0	3091.2	100	4	72.3	ON	110	70.8	4	39.6	57.85
5/8/2011	4:45:00	0	3099.2	100	4	76.3	ON	110	77.8	4	40.3	57.9
5/8/2011	5:00:00	0	3107.2	100	4	70.3	ON	110	72.3	4	39.8	57.7

Trend Logs

- Virtually all Building Automation Systems have trend logging capabilities
- Few have them set up and enabled!
- Many facilities which have trend logs set up do not use them

Trend Logs as Virtual Testing

- Trend-logging is a powerful analysis tool
- Better than functional testing because it shows system integration effects and the impact of dynamic loads
- Better than BAS graphic review because it is not a snapshot…it exhibits system behavior over time

Setting Up Trend Logs

- System memory must be analyzed to make sure it has sufficient capacity (especially with older systems)
- Decide how many points are to be trended and in what intervals
  - Recommend intervals no less than 5 minutes and no greater than 15 minutes between data points.

Data Mining

- "Data mining" is the process of interpreting the trend logs
- This can be done with a combination of graphing and calculations

Graphing the Data

- Plot the data using a software tool (Excel, Hoboware Pro, Matlab, etc.)
- *Onset* "Hoboware" is great for big picture
  - Allows you to pan and zoom in on data
- Excel is great for the data mining
  - Allows you to perform more elaborate checks, filters, and apply formulas to the raw data

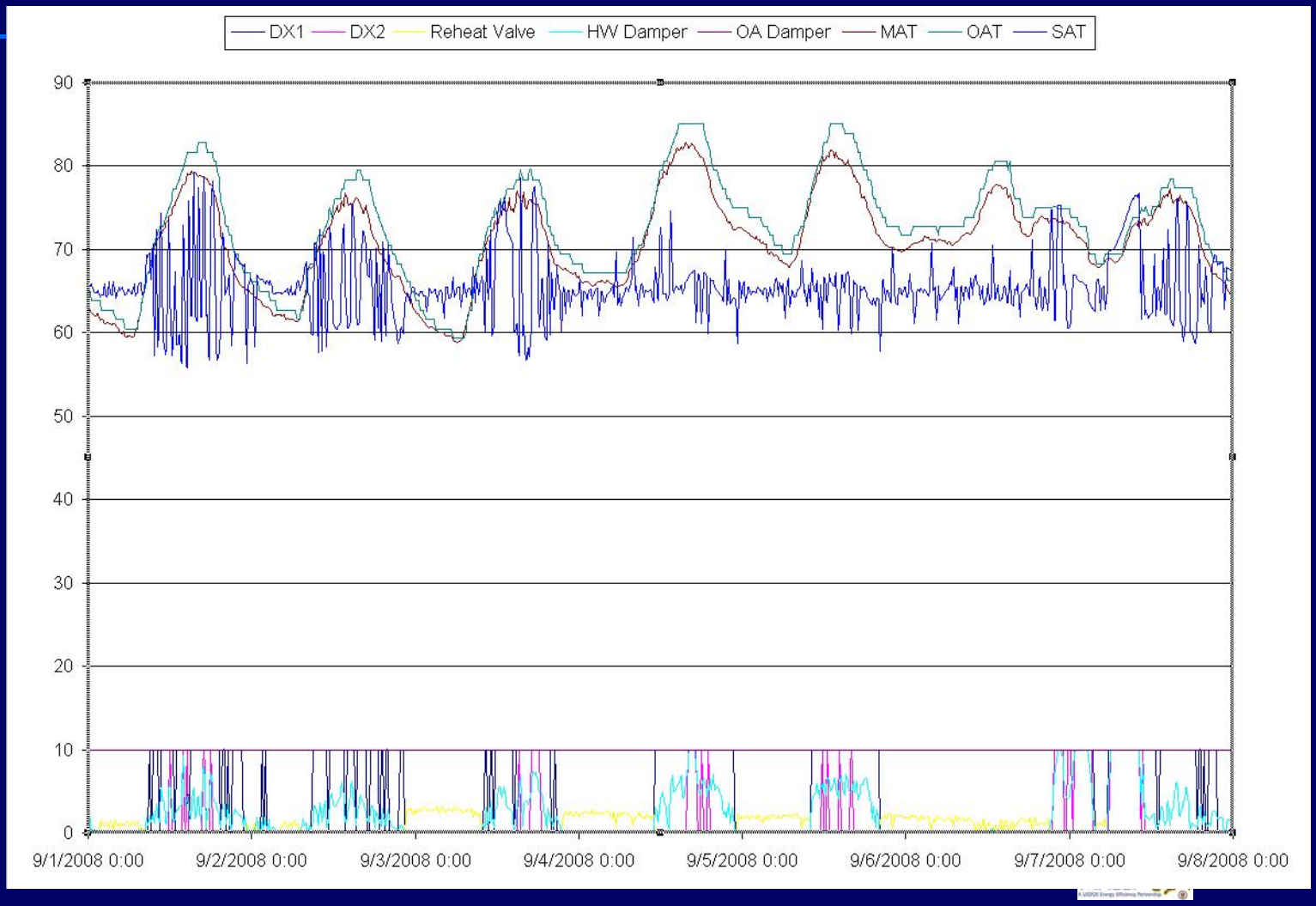
Graphical Analysis of Trend Logs

- Look for sudden changes in any of the trends
- Look for data that doesn't make sense!
  - Equipment that shouldn't be running
  - Temperatures higher/lower than expected
  - Rapid cycling of valves/dampers
- Make note of smaller time intervals that will need a closer look

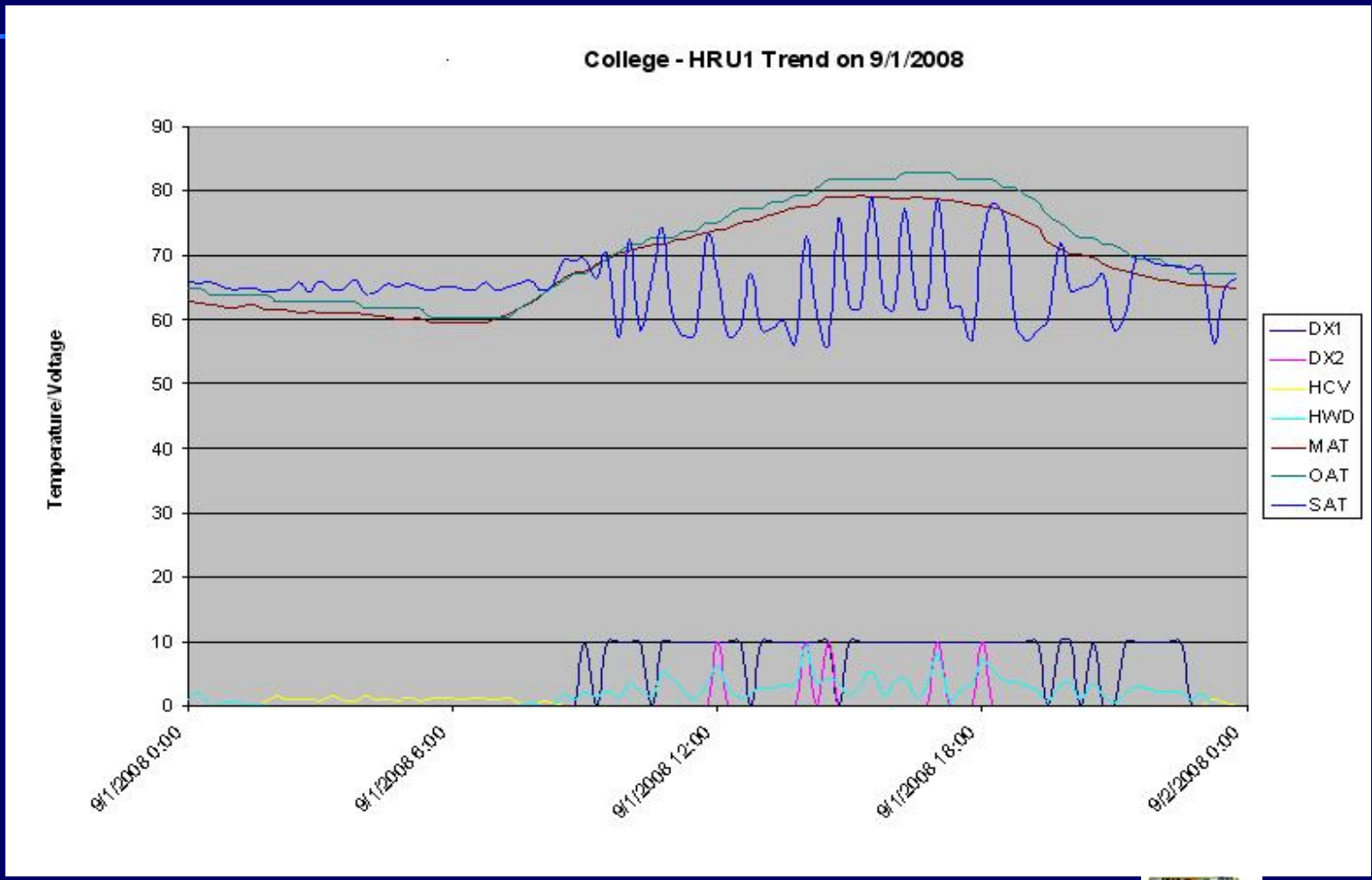
Telescoping In

- Plot several smaller data sets that need a closer look
  - These can be used as “evidence” in trend log reports
- When studying potential issues, think in terms of system interactions
- Look for common RCx opportunities

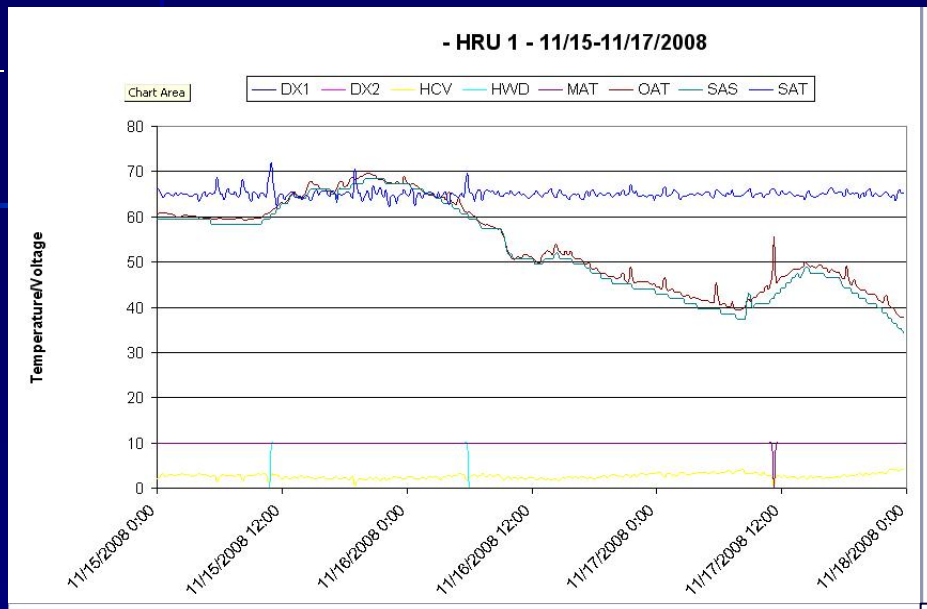
One Week Trend

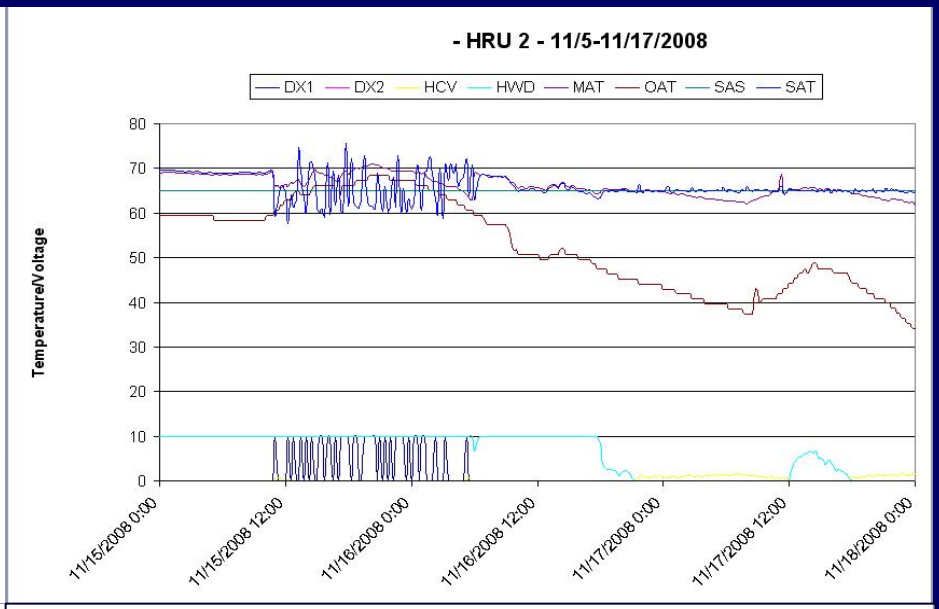


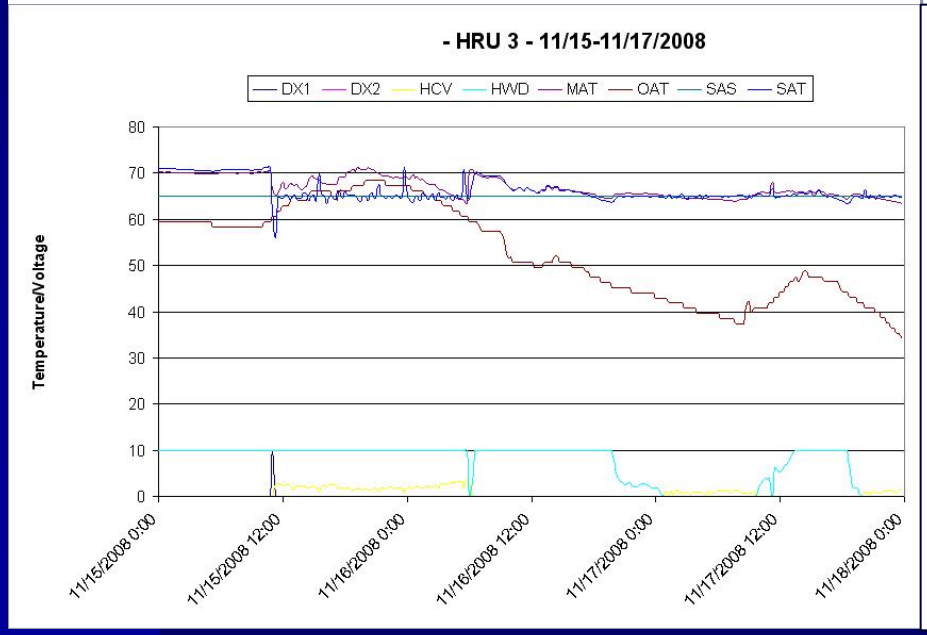
Example: A 1-Day Trend

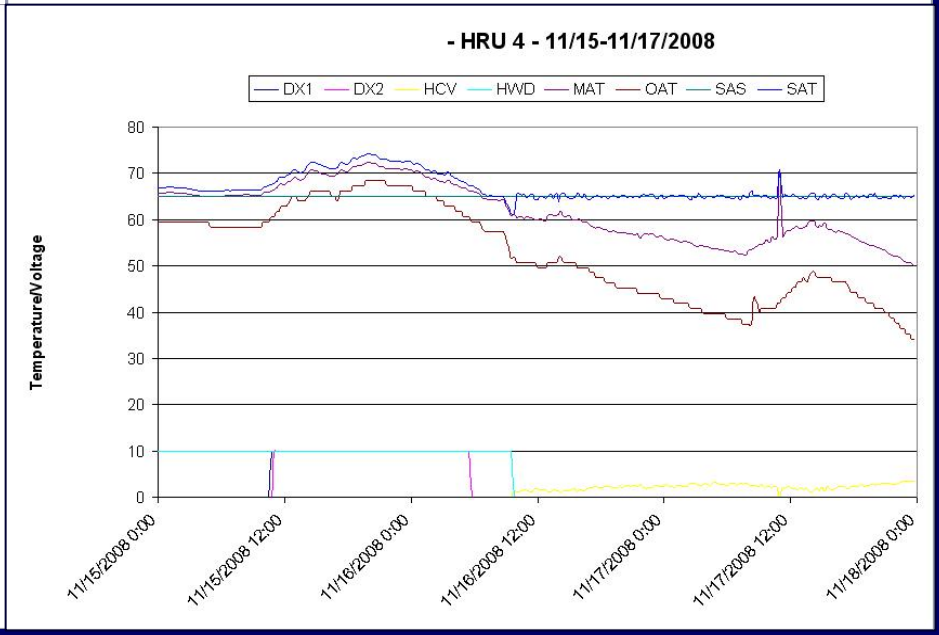


Identical Units During Same Time & Dates









Using Excel amd Formulas to Analyze Data

Cooling engaged = 10

This column was created to identify when cooling was engaged at outside air temperatures below 65F

9/11/2008 19:45	10	0	0	2.28	69.15	63.85	65	69.48	22.8	0	22.8	1
9/11/2008 20:00	10	0	0	2.77	69.12	62.73	65	69.94	27.72	0	27.72	1
9/11/2008 20:15	10	0	0	2.48	69.03	62.73	65	66.1	24.83	0	24.83	1
9/11/2008 20:30	0	0	0	0.31	69.1	62.73	65	56.4	3.11	0	3.11	0
9/11/2008 20:45	0	0	0	0.32	69.08	61.62	65	60.86	3.18	0	3.18	0
9/11/2008 21:00	0	0	0	1.12	69.03	61.62	65	66.29	11.18	0	11.18	0
9/11/2008 21:15	0	0	0	1.75	68.96	61.62	65	68.59	17.55	0	17.55	0
9/11/2008 21:30	10	0	0	2.49	69.15	61.62	65	69.69	24.9	0	24.9	1
9/11/2008 21:45	10	0	0	2.55	69.23	60.5	65	66.92	25.53	0	25.53	1

Outside Air Temperature

Testing Controls Hardware

- Conduct point-to-point check out-is it necessary?
- Verify operation of end devices: coil control valves and damper operation
- Inspect sensor/instrumentation locations
- Verify calibration

Example: Point-to-Point Checkout

EnergyNet Controller			Infinet Controller				
Name: CX01_Quad1	Battery Tab Removed:	Name: PH01	Serial #: 92770 (2)	Exp-1:	Power Source:
ID #: 1	3.8V (1)	Type: SCX920	Description: Lazer Craze	Exp-2:	Location:
Port: Comm2		ID#: 11	Location:	Notes:	Demolition Complete:

Inputs			End Device Material List		Configuration									Integrity Validation					
							Elect. Units		Eng. Units								PRE-TEST VALUES		FINAL VALUES	
CHAN	POINT NAME	DESCRIPTION	PART NO.	MANUFACTURER	TYPE	UNITS	BOT	TOP	BOT	TOP	TREND	INV	ALRM	INSTALLED	ASSIGNED	RESISTOR POS.	FRONT END	HAND HELD	FRONT END	HAND HELD
1	FilterStatus	Filter Status	T3C-C1C	MODUS	Voltage	In. WC	1	5	0	1	X		X	(1)	(1)	OFF	.3"	.3"	.25"	.25"
2	SupAirTemp	Supply Air Temperature		Andover Controls	ACCTemp	Deg. F	0	0	0	0	X		X	(2)	(2)	ON	78.7	78.5		
3	RetAirTemp	Return Air Temperature		Andover Controls	ACCTemp	Deg. F	0	0	0	0	X		X	(3)	(3)	ON	70.6	69.1		
4	MixedAirTemp	Mixed Air Temperature AVG		Greystone	ACCTemp	Deg. F	0	0	0	0	X		X	(4)	(4)	ON	102.6	96.4		
5	RetSmkDet	Return Smoke Detector			Digital	On=Alarm	0	0	0	0		X	X							
6	HtgCoilTemp	Heating Coil Temperature AVG		Greystone	ACCTemp	Deg. F	0	0	0	0	X		X	(7)	(7)	ON	84.6	84.6		
7	SupSmkDet	Supply Air Smoke Detector			Digital	On=Alarm	0	0	0	0		X	X							
8	SupStaticPress	Supply Air Static Pressure -	T3C-C1C	MODUS	Voltage	In. WC	1.19	7.5	0	1.6	X		X	(8)	(8)	OFF	.26"	.22"	.118"	.115"
9	SupPressHi	High Supply Air Static Pressure	1900-5 MR	Dwyer	Digital		0	0	0	0	X	X	X	(9)	(9)	ON		3.6"		
10	SupPressLo	Low Supply Air Static Pressure	1900-5 MR	Dwyer	Digital	On=Low	0	0	0	0	X	X	X	(10)	(10)	ON		2"		
11					Voltage	RH	1	5	0	1	X		X							
12	RmTemp1	Room Temperature		Andover Controls	ACCTemp	Deg. F	0	0	0	0	X		X	(11)	(11)	ON	70.4	69.5		
13	RmTemp2	Room Temperature		Andover Controls	ACCTemp	Deg. F	0	0	0	0	X		X	(12)	(12)	ON	69.7	69		
14	RetAirHumidity	Return Air Relative Humidity			Voltage	RH	1	5	0	1	X		X	(13)	(13)	OFF	15,406	23,396		
15	SupFanStatus	Supply Fan Status	722	Hawkeye	Voltage	Amps	0	8.5	0	10.0	X		X	(14)	(14)	OFF	7.5A	5.5A	5.5A	5.5A
16					Voltage	RH	1	4	0	1	X		X							
17	LoTempSwitch	Low Temperature Switch (A)	A-70CA-1	Penn	Digital	On=Freeze	0	0	0	0	X	X	X	(15)	(15)	ON				
18	UPS_11	UPS_11 Network Rm11			Digital	On=Alarm	0	0	0	0	X	X	X							

Outputs			End Device Material List		Configuration									Integrity Validation					
							Elect. Units		Eng. Units								PRE-TEST VALUES		FINAL VALUES	
CHAN	POINT NAME	DESCRIPTION	PART NO.	MANUFACTURER	TYPE	UNITS	BOT	TOP	BOT	TOP	TREND	INVERT	ALRM	INSTALLED	ASSIGNED		FRONT END	ACTUAL	FRONT END	ACTUAL
1	SFC_01	Supply Fan S/S			Digital		0	0	0	0	X		X	(1)	(1)					
2	SFS_06	Supply Fan Speed			Current		4	20	0	1	X		X	(2)	(2)					
3	TCV_3B	CHW Valve Modulation			Current	Open	4.7	22.9	0	1	X		X	(3)	(3)					
4	BypDmp	Bypass Damper			Current	Open	6.7	19.1	0	1	X		X	(4)	(4)					
5	TCV_4C	Max OA Dampers			Current	Open	6.258	.15 K	0	1	X		X	(5)	(5)					
6	TCV_4A	Return Air Dampers			Current	Open	10.16	4	0	1	X		X	(6)	(6)					
7	TCV_4B	Min. OA Damper			Current	Open	4.5	17.8	0	1	X		X	(7)	(7)					
8	TCV_3A	Steam Valve Modulation			Current	Open	14	8.4	0	1	X		X	(8)	(8)					
9	TCV_11	Discharge Air Damper -			Current	Open	7	14	0	1	X		X							
10	TCV_12	Discharge Air Damper			Current	Open	7	14	0	1	X		X	(9)	(9)					

Miscellaneous parts		End Device Material List	
QTY	DESCRIPTION	PART NO.	MANUFACTURER

Hardware Commissioning Sign-Off Legend			
Tag	Date	Initials	Signature
(1)	11-3-08	JZ	

Commissioning Legend (Miscellaneous)
N/I = Not Installed
N/C = Not Complete
N/A = Not Applicable

	SCALE	DRAWN BY:
North Andover, MA	NONE	APPROVED BY:
POINT LIST & COMMISSIONING SHEET FOR CX01_Quad1 PH01		
Date: 5/23/2008	Rev #: 1	Drawing Name: H-039

MAEEP

Functional Testing

- Field Testing of Controls Software Algorithms
  - Create tests which simulate the sequence of operation
  - Conduct relative calibration tests
  - Check Communications
  - Check data archiving
  - Review Trend Logs
  - Seasonal testing