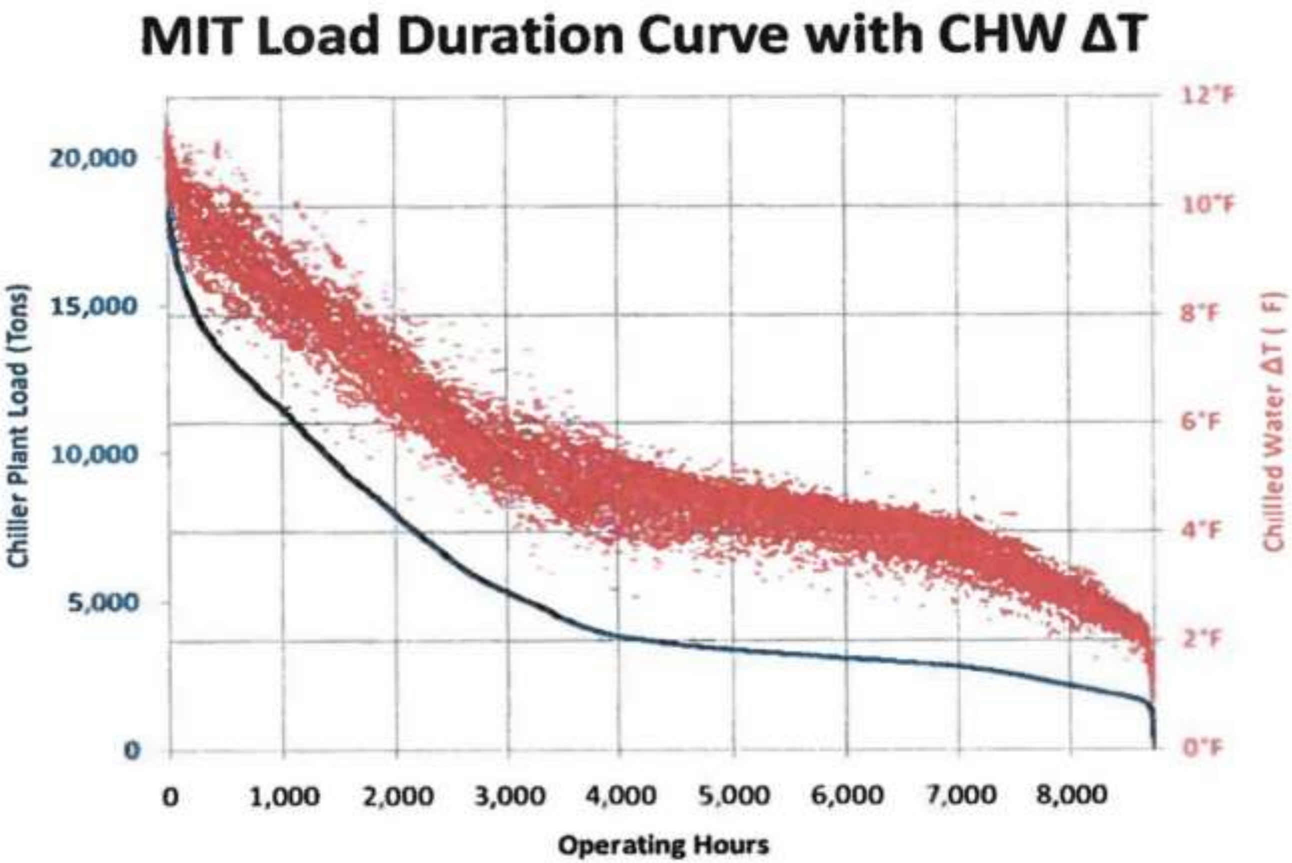
Eliminating the High Cost of Over Pumping

Eliminating the High Cost of Over Pumping

- Flow Study and Pumping Cost Analysis
- System Design and Sizing (Valve-Coils-Chillers)
- Pressure Independent Valves/Dynamic Balancing
- Delta T Management, Correcting Low Delta T
- Case Studies
- Data Analysis, Optimization and Functionality
- Calculate Savings
- Heating Applications
- Systems Running as Designed

Independent Energy Modeling Study
Chilled Water System, Average Delta T = 6
Peak Load 26,000 Tons



*** From 2008 Chilled Water Delta T Study**

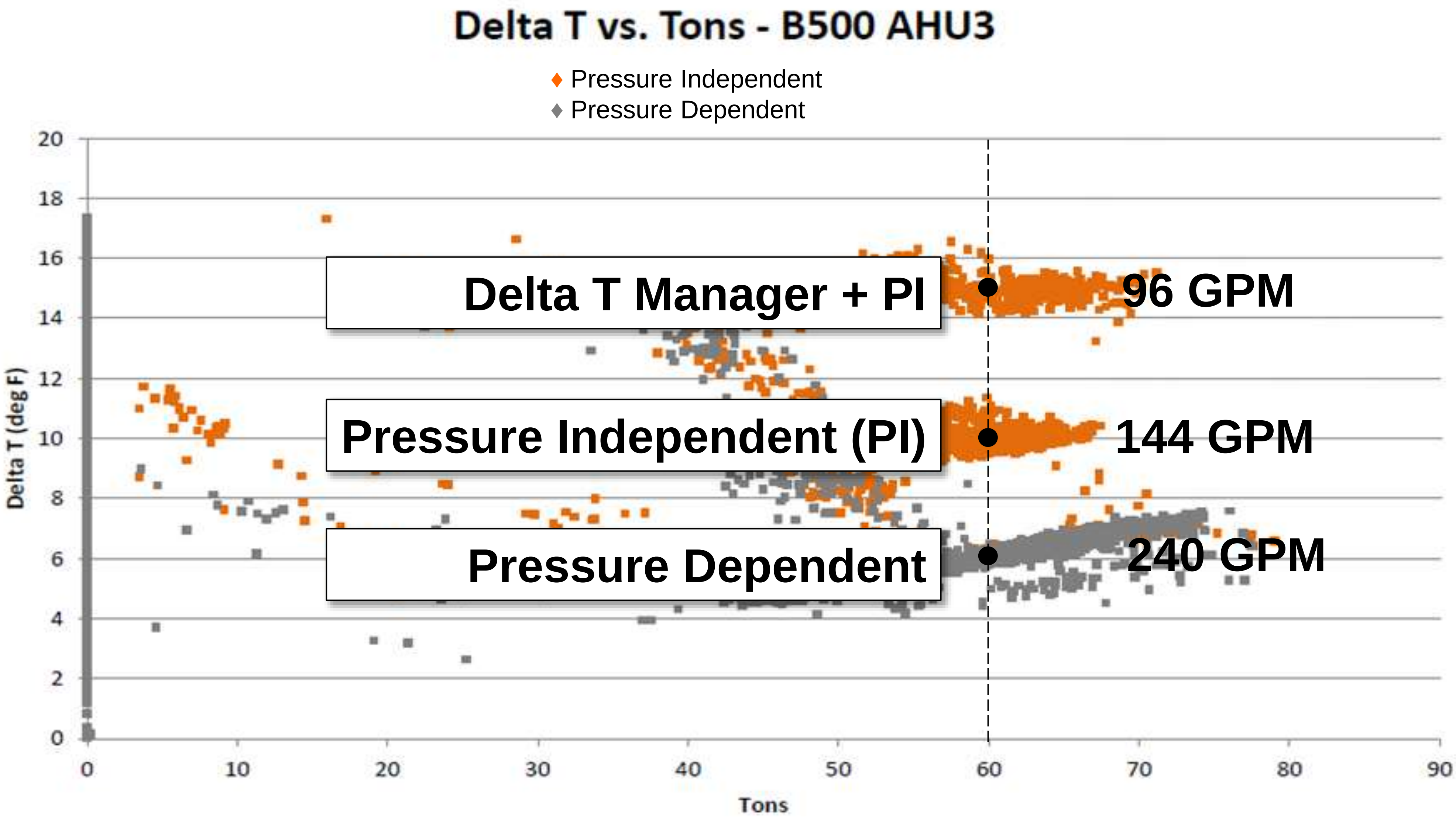
Independent Study
Savings by Eliminating Low Delta T
Increase DT from 6 to 12 degrees (12 = Design)

Recommend implementing chilled water delta T improvement projects across the campus.

Component	Annual Energy Savings	Annual Cost Savings
Chiller Steam	10,887 Mlbs	$181,000.00
Chiller Electric	2,576,000 kWh	$412,000.00
CHW Pump Electric	2,334,000 kWh	$373,000.00
CW Pump Electric	2,417,000 kWh	$387,000.00
CT Fan Electric	740,000 kWh	$118,000.00
TOTAL SAVINGS		**$1,471,000.00**

25% of Total

Pressure Independent & Delta T Manager
Pump Savings in Large Tech Company in NC



Belimo Energy Valve™ Savings Estimator

Project	33 Turner Road, Danbury, CT
Sample Site	Version 1.0 / 2 Chillers / Simple static pressure pump control
Climate Region	North East

INPUT DATA: VARIABLE FLOW CHILLED WATER PLANT

	Value	Unit
Electricity Cost (Average)	0.10	$/kWh
Chilled Water Plant Load (Design Cooling Load)	500	tons
Number Of Chillers	2	pcs.
Operating Hours / Day	24	hours
Operating Days / Week	7	days
Chiller Efficiency (IPLV)	1	kW/ton
Actual Pump Head (Design)	120	ft.
Min. Pump Head	40	ft.
Pump, Vfd, Motor Efficiency (Average)	60	%
Design Delta T	12	°F
Actual Delta T (Prior Energy Valve Installation)	6	°F
Future Delta T (Energy Valve Delta T Manager Setting)	12	°F

ANNUAL ENERGY COSTS

Delta-T [°F]	Flow [GPM]	Pumping Cost	Chiller Cost	Total Cost	Energy [kWh]
5	1333	$ [illegible]	$ 222,817	$ 251,538	2,515,384
6	1333	$ 24,098	$ 220,322	$ 244,420	2,444,197
8	1333	$ 17,436	$ 215,331	$ 232,767	2,327,666
10	1200	$ 12,848	$ 210,339	$ 223,187	2,231,869
12	1000	$ 9,773	$ 205,348	$ 215,122	2,151,216
13	923	$ 8,668	$ 202,853	$ 211,520	2,115,202
Annual Energy Savings				292,981	kWh
Annual Cost Savings (Cash Flow)				29,298	$

INPUT FINANCIALS

	Value	Unit
Incremental Investment for Energy Valves	50,000	$
Discount Rate	10	%
Annual Inflation Rate on Energy Costs	3	%

FINANCIAL ANALYSIS RESULTS

Investment Horizon	5 years	10 years	15 years	20 years
Accounting Rate of Return	62%	67%	73%	79%
Net Present Value (NPV)	$67,269	$151,681	$212,442	$256,179

GREENHOUSE GAS EQUIVALENTS

	Value	Unit
Annual Carbon Dioxide Avoided	455,586	pounds
Annual Carbon Dioxide Avoided	207	metric tons
Equivalent to Number of Houses' Annual Electricity Use	28	homes

DISCLAIMER

At 50% load and 6 degrees DT flow = 1000 GPM

Increasing DT to 12 degrees (design) flow reduces to 500 GPM

Chilled Water Distribution Flow at Delta T [F]:				6
Load [%]	Time [%]	Time [h]	Flow [GPM]	Head [ft]
100	6	526	1333	139
75	15	1314	1333	139
50	35	3066	1000	120
25	44	3854	500	85

Chilled Water Distribution Flow at Delta T [F]:				12
Load [%]	Time [%]	Time [h]	Flow [GPM]	Head [ft]
100	6	526	1000	120
75	15	1314	750	104
50	35	3066	500	85
25	44	3854	250	60

Pump Affinity Laws

$$\frac{RPM_1}{RPM_2} = \frac{GPM_1}{GPM_2} \qquad \frac{HEAD_1}{HEAD_2} = \left(\frac{RPM_1}{RPM_2}\right)^2 \qquad \frac{HP_1}{HP_2} = \left(\frac{RPM_1}{RPM_2}\right)^3$$

$$HP = \frac{GPM \times HD \times \text{Specific Gravity}}{3960 \times \text{Pump Efficiency}}$$

Control Valve Sizing

Pressure Dependent Flow Coefficient-Valve Sizing (CV)

$$Cv = \frac{GPM}{\sqrt{\Delta P}}$$

- **1 Cv = 1 gallon of 60 DegF water passing through a fully open control valve with a pressure drop of 1 psi.**
- **Sizing is typically done using a PD of 3-5 PSI**
- **Manual balancing can not maintain a constant PD and causes overflow and low delta T.**

when the pressure drop increases the flow increases

Balancing Valve Sizing & Selecting

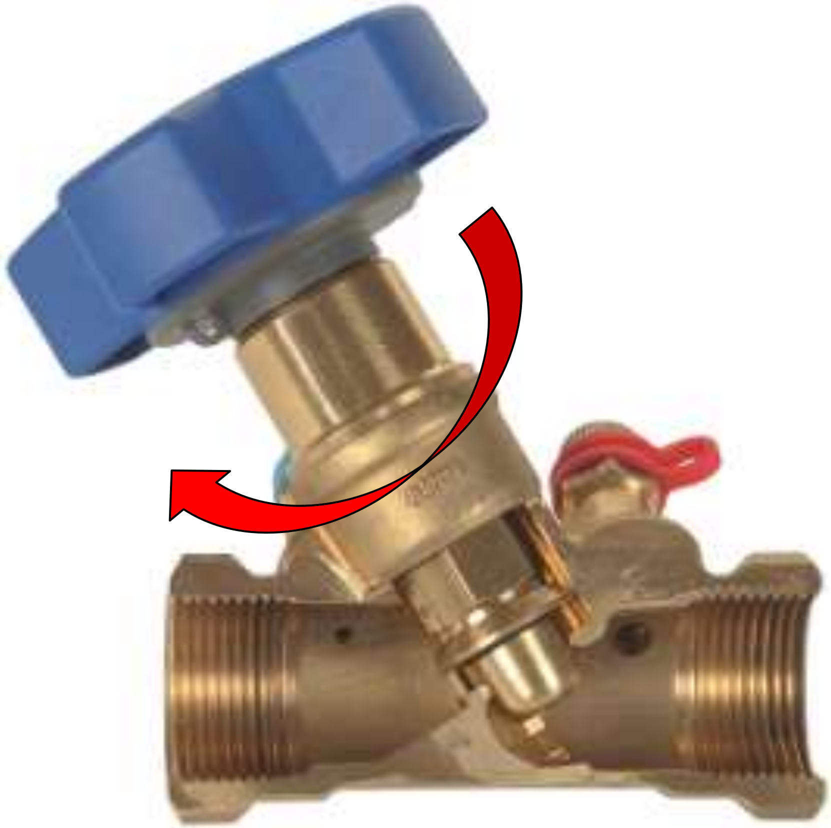
Balancing valves are sized based on GPM. Sizing is generally done using the "nominal flow" (not max or min flow)

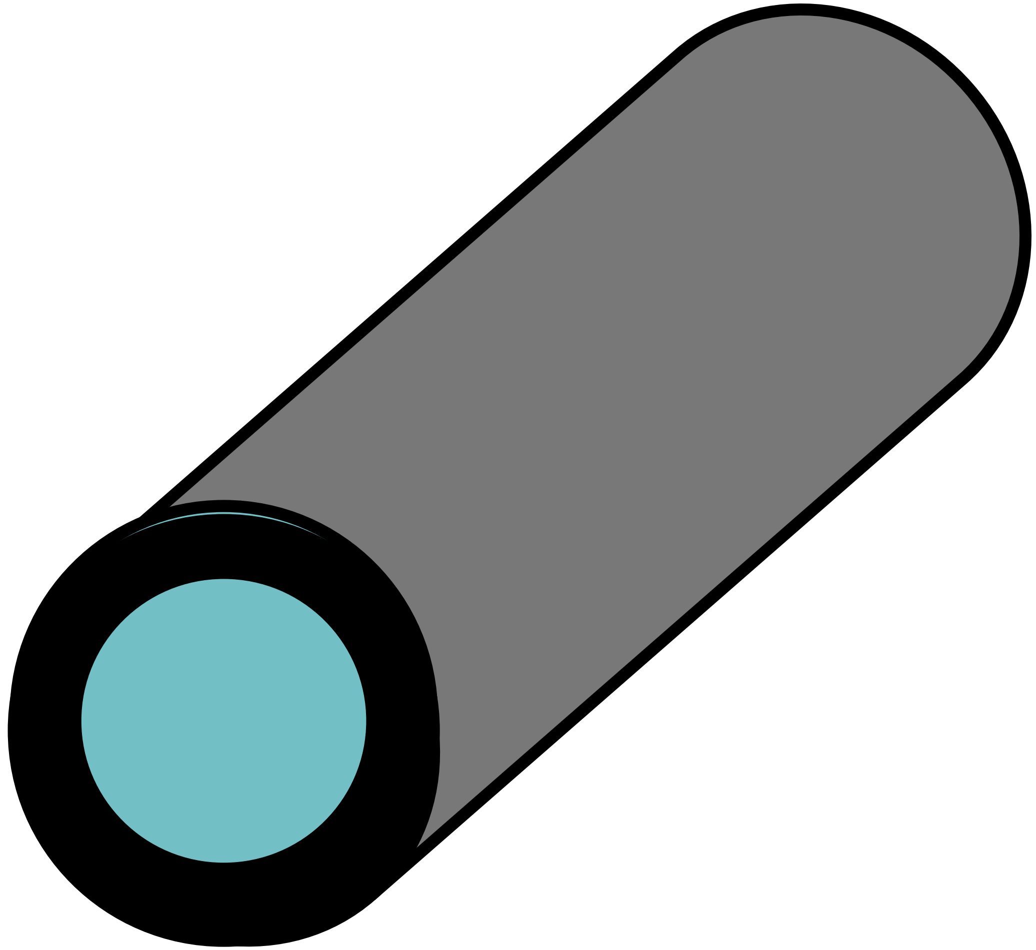
Setting is done by rotating a handle and adjusting the CV to achieve a specific pressure drop.

Balancing Valves are set for one pressure drop and are effected by pressure changes.

when the pressure drop increases the flow increases

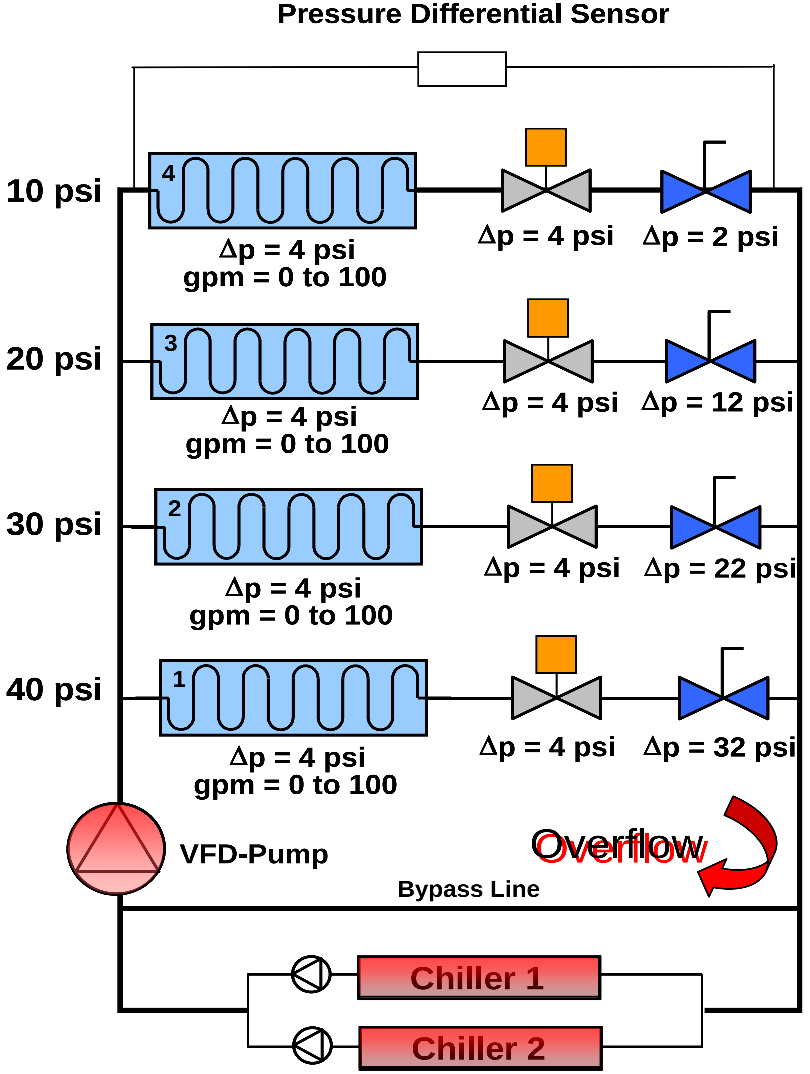
Manual Balancing Valves

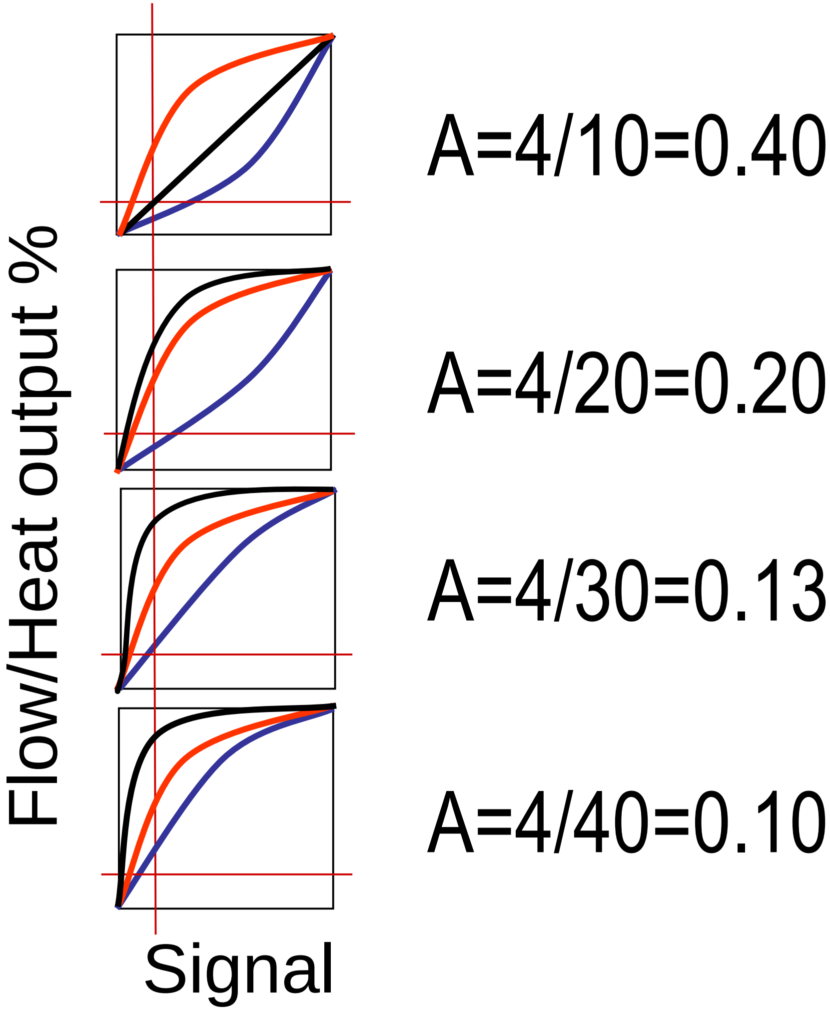




when the pressure drop increases the flow increases

Why Systems Over Flow?
Valve Authority





Accumulative Waste

Typical Chilled Water Design

Flow and delta T are inversely proportional; for a given load, when delta T drops flow has to increases.

$$\text{GPM} = \frac{\text{Tons} \times 24}{\Delta\text{T}}$$

$$2000\ \text{GPM} = \frac{\text{Tons} \times 24}{12°\Delta\text{T}}$$

$$2000\ \text{GPM} = \text{Tons} \times 2$$

$$\frac{2000\ \text{GPM}}{2} = \text{Tons}$$

$$\text{Tons} = 1000$$

Cost of Overflow at the Plant

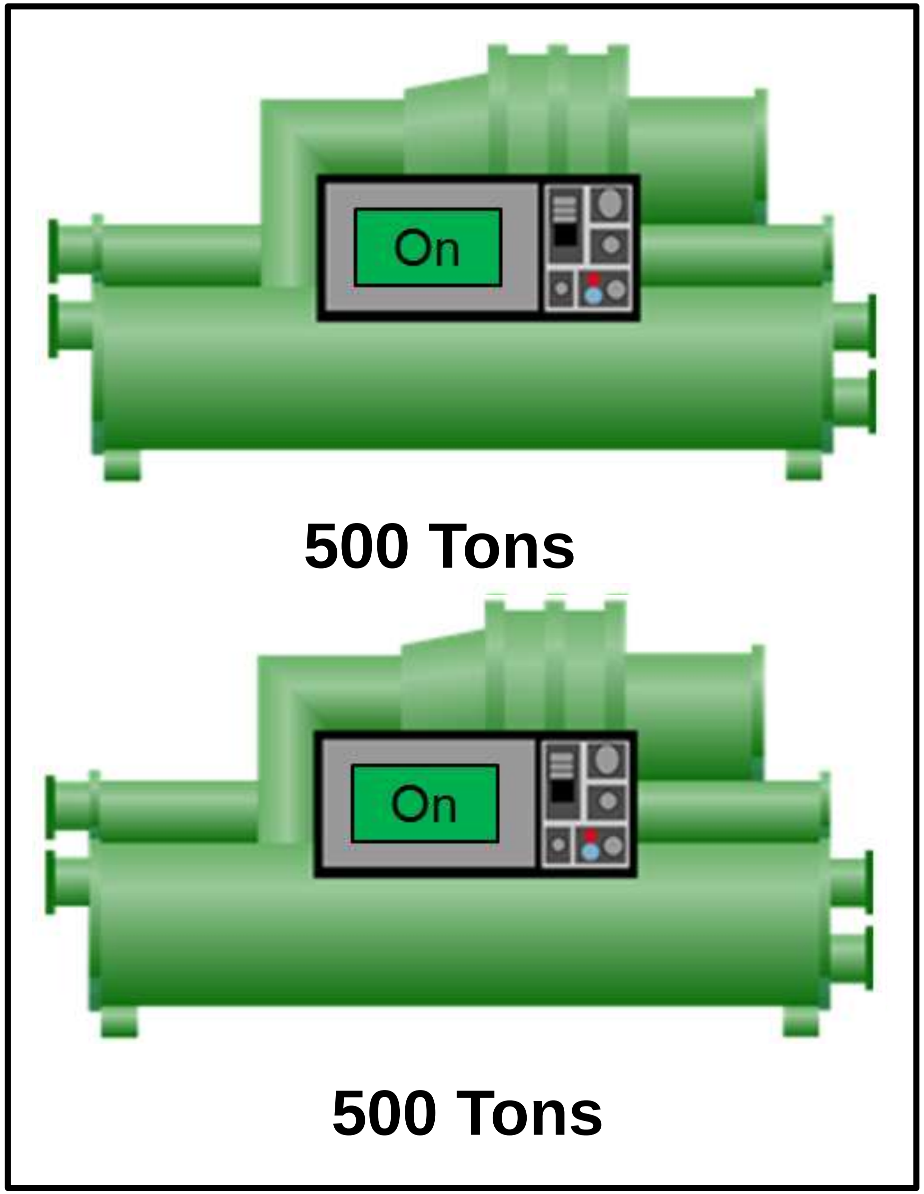
Plant Efficiency

- **Chillers**
  - Plant is more efficient at Design ΔT than at low ΔT
  - Low DT (high flows) can cause Improper staging

$$GPM = \frac{Tons \times 24}{\Delta T}$$

$$GPM = \frac{500 \times 24}{\color{red}{12}} = 1{,}000$$

$$GPM = \frac{500 \times 24}{\color{red}{8}} = 1{,}500$$



Chilled and Hot Water Coil Design

CHW Coil= GPM, EWT=44, LWT=60, DT=16

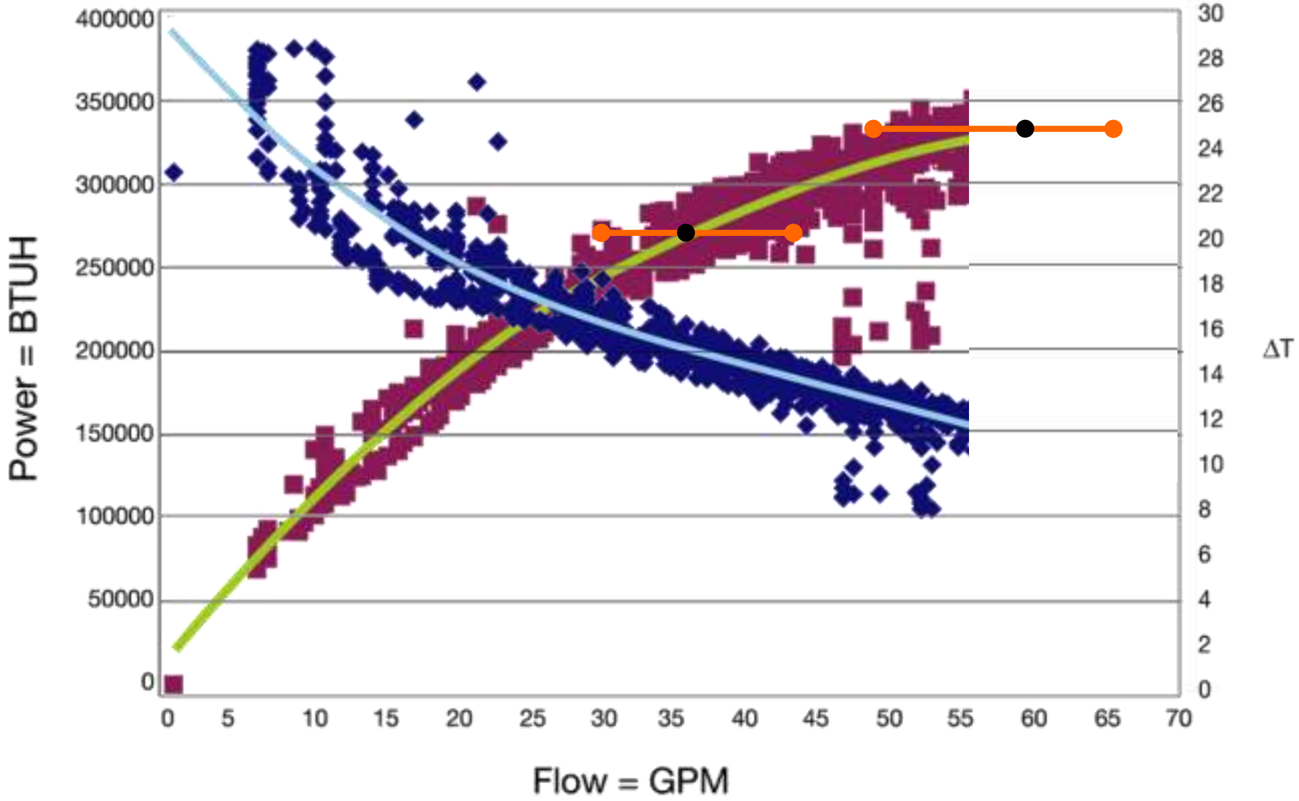
HW Coil = GPM, EWT=140, LWT=120, DT=20

CHW DT= 8 will increase pumping X 2, Increase cost X 8.

	FAN SECTIONS												
UNIT NO	LOCATION	SERVES	VENTILATION DES.	VENTILATION MIN.	CFM	EXT. SP	WHEEL TYPE	FAN RPM	MAX BHP	ELECTRICAL HP	ELECTRICAL VOLTS	ELECTRICAL PH	ELECTRICAL RPM
AHU-1	BSMT WEST MER	WEST LEVEL A & 1	7,000	1,247	19,733	2.00"	PLENUM	1718	26.7	(2) 15	480	3	1750
AHU-2	BSMT WEST MER	CLASSROOM A17	854	111	2,560	1.25"	PLENUM	3852	2.77	5	480	3	1750
AHU-3	BSMT WEST MER	FORUM	2,432	168	4,825	2.00"	PLENUM	2350	7.10	7.5	480	3	1750
AHU-4	BSMT WEST MER	SOUTH ATRIUM	6,585	589	8,860	2.00"	PLENUM	2218	11.28	(2) 7.5	480	3	1200
AHU-5	BSMT EAST MER	EAST	1,100	106	6,525	2.00"	PLENUM	2181	7.88	10	480	3	1750
AHU-6	BSMT EAST MER	CLASSROOM A71	887	109	2543	1.25"	PLENUM	2810	2.98	5	480	3	3600
AHU-7	PENTHOUSE	CHILLED BEAMS	19,200	8,231	22,163	2.00"	PLENUM	2475	51.35	(3) 20	480	3	1750
AHU-8	PENTHOUSE	WEST LEVEL 2 & 3	6,300	1,372	19.875	2.00"	PLENUM	1696	25.57	(2) 15	480	3	1750
AHU-9	PENTHOUSE	CHILLED BEAMS	8,000	3,872	10,402	2.00"	PLENUM	2539	16.79	(2) 10	480	3	1200
AHU-10	PENTHOUSE	AHU-5,6, & 8	7,687	7,687	7,687	2.00"	PLENUM	2303	8.39	(2) 5	480	3	1750

	HOT WATER COIL										CHILLED WATER COIL									
UNIT NO	CAP MBH	AIR DATA EAT	AIR DATA LAT	WATER DATA EWT	WATER DATA LWT	WATER DATA GPM	VEL FPM	AIR PD	WATER PD	ROWS FINS	CAP MBH	AIR DATA EAT	AIR DATA LAT	WATER DATA EWT	WATER DATA LWT	WATER DATA GPM	VEL FPM	AIR PD	WATER PD	ROWS FINS
AHU-1											511.4/468.2	76.1/62.9F	54.5/54.1F	44	60	63.7	512	0.611"	3.83'	6/113 FPF
AHU-2	69.4	50.0	75.0	140	120	7.0	480	0.114"	0.22'	1/135 FPF	96.3/75.6	76.9/63.2F	50.0/49.9F	44	60	12.0	480	1.006"	6.67'	8/141 FPF
AHU-3	133.5	50.0	75.0	140	120	13.4	438	0.079"	0.69'	1/112 FPF	223.8/147.6	77.2/65.5F	50.0/49.9F	44	60	29.7	417	0.844"	4.59'	8/140 FPF
AHU-4	240.2	50.0	75.0	140	120	24.1	368	0.051"	1.31'	1/98 FPF	502.9/293.5	79.0/68.0F	49.0/48.9F	44	59	62.7	368	0.680"	11.25'	8/133 FPF
AHU-5											167.8/149.8	75.4/62.73F	54.5/53.9F	44	60	20.1	497	0.542"	2.25'	6/103 FPF
AHU-6	69.0	50.0	75.0	140	120	6.91	477	0.085"	0.84'	1/123 FPF	96.1/76.0	77.2/63.3F	50.0/49.9F	44	60	11.97	477	0.989"	17.61'	8/140 FPF
AHU-7	513.7	45.0	55.0	140	120	80.6	514.6	0.090"	1.42'	1/123 FPF	1328.4/ 689.9	77.5/69.0F	50.4/50.3F	44	60	(2)106.7	489.6	1.12"	20.68'	10/139 FPF
AHU-8											522.9/475.9	78.1/62.9F	54.3/53.9F	44	60	65.2	516	0.637"	3.99'	8/115 FPF
AHU-9	270.0	50.0	75.0	140	120	27.0	514.6	0.090"	1.42'	1/123 FPF	750.4 329.8	78.8/72.8F	50.4/50.3F	44	60	93.5	363	0.649"	9.32'	8/116 FPF
AHU-10																				

Low Delta T at the Coil
Delta T Decreases, Flow Increases
No Additional Heat Transferee



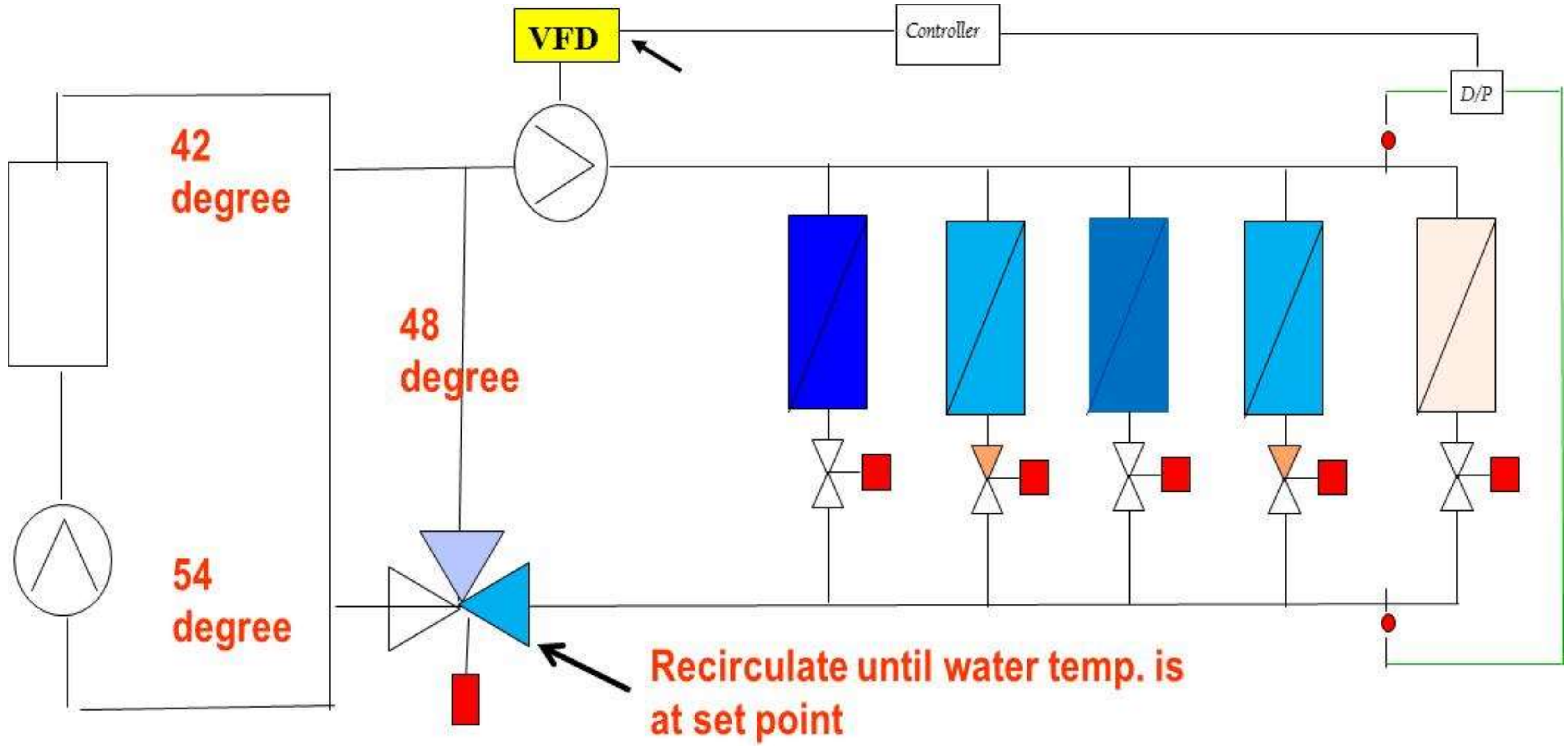
<u>Operating in the Waste Zone</u>

1. Pumping more Water
2. Reduced Delta T
3. No additional BTUs

Power Output: $$Q(\text{Btu/h}) = 500 \times GPM \times \Delta\text{T}$$

Design, Not the Solution

Deny or Choke Valve, will not allow a coil to run as designed. This application will negate proper de-humidification and comfort.



Causes of Low Delta T

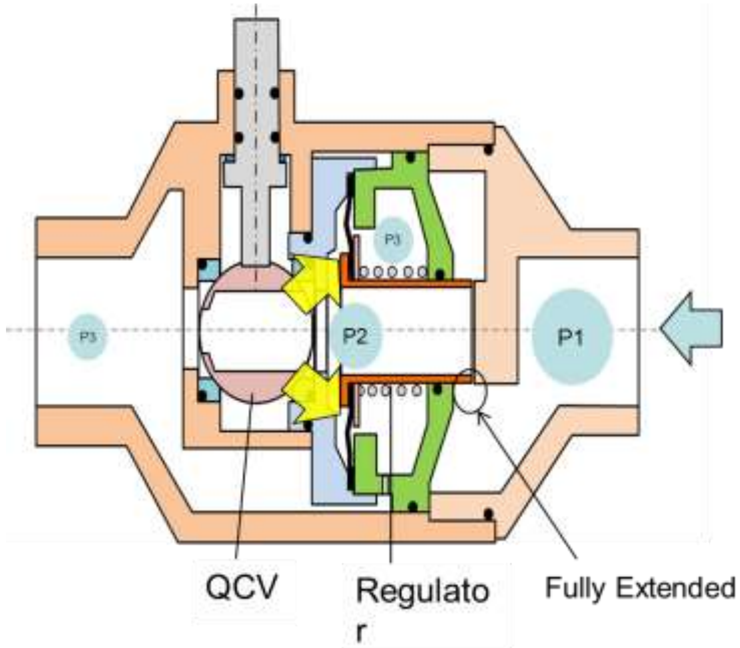
- **Oversized chillers, pumps, coils, control valves and piping**
- **Controlling the chilled water valve using only the air sensor is insufficient**
- **Manual balancing only addresses one flow condition**
- **Systems rarely run at full load causing overflow at part load**
- **Hydronic systems are changed but not rebalanced**






Correcting Low Delta T
Delta T Management
.5” thru 6”– .5 thru 713 GPM

Terminal Unit Pressure Independent Valve

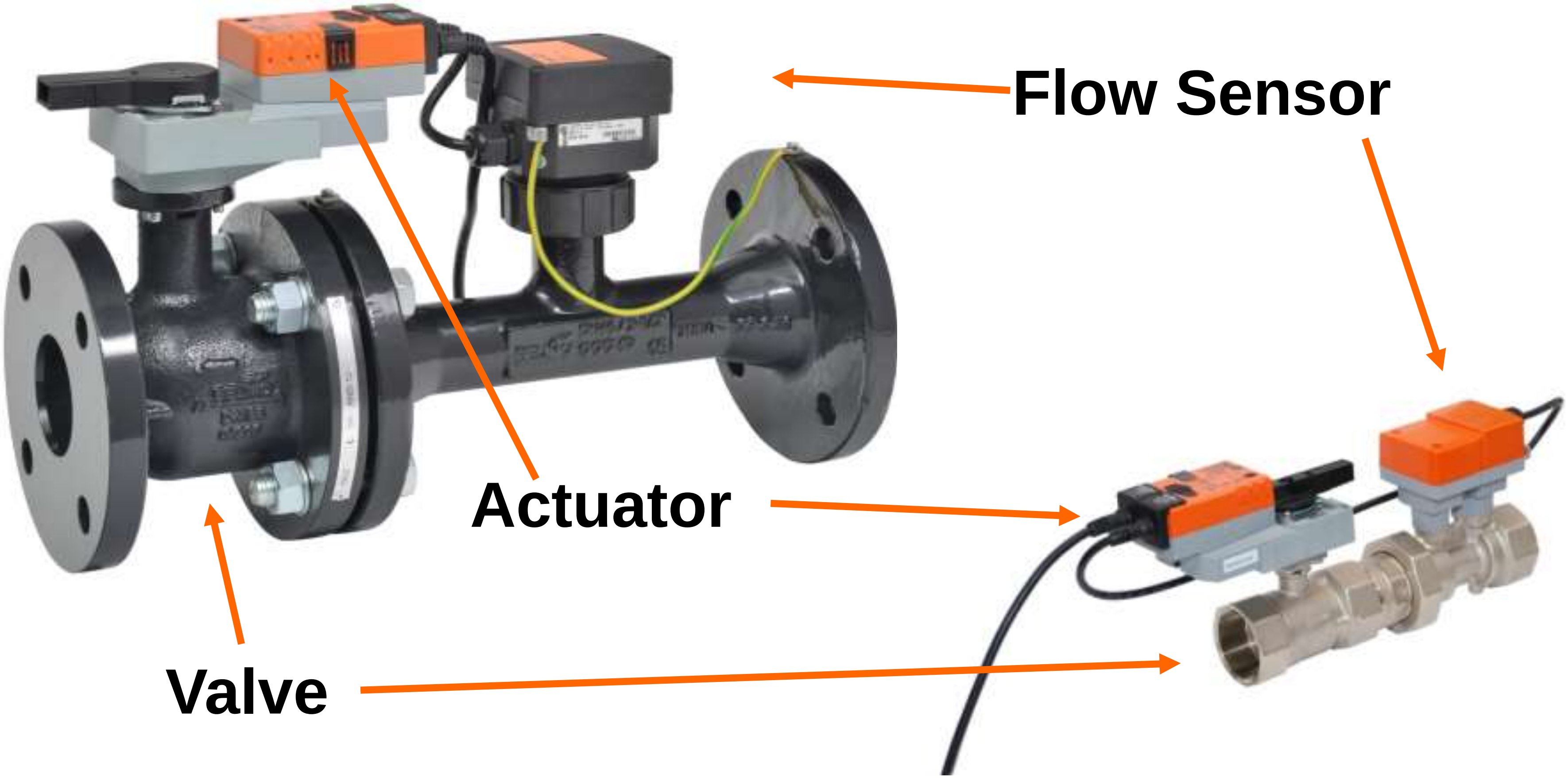


2-Way PIQCV (Pressure Independent)
½" and ¾" NPT, Fail Last or Fail Safe
Up to 9 GPM
100 PSI Close Off

Mechanical operation

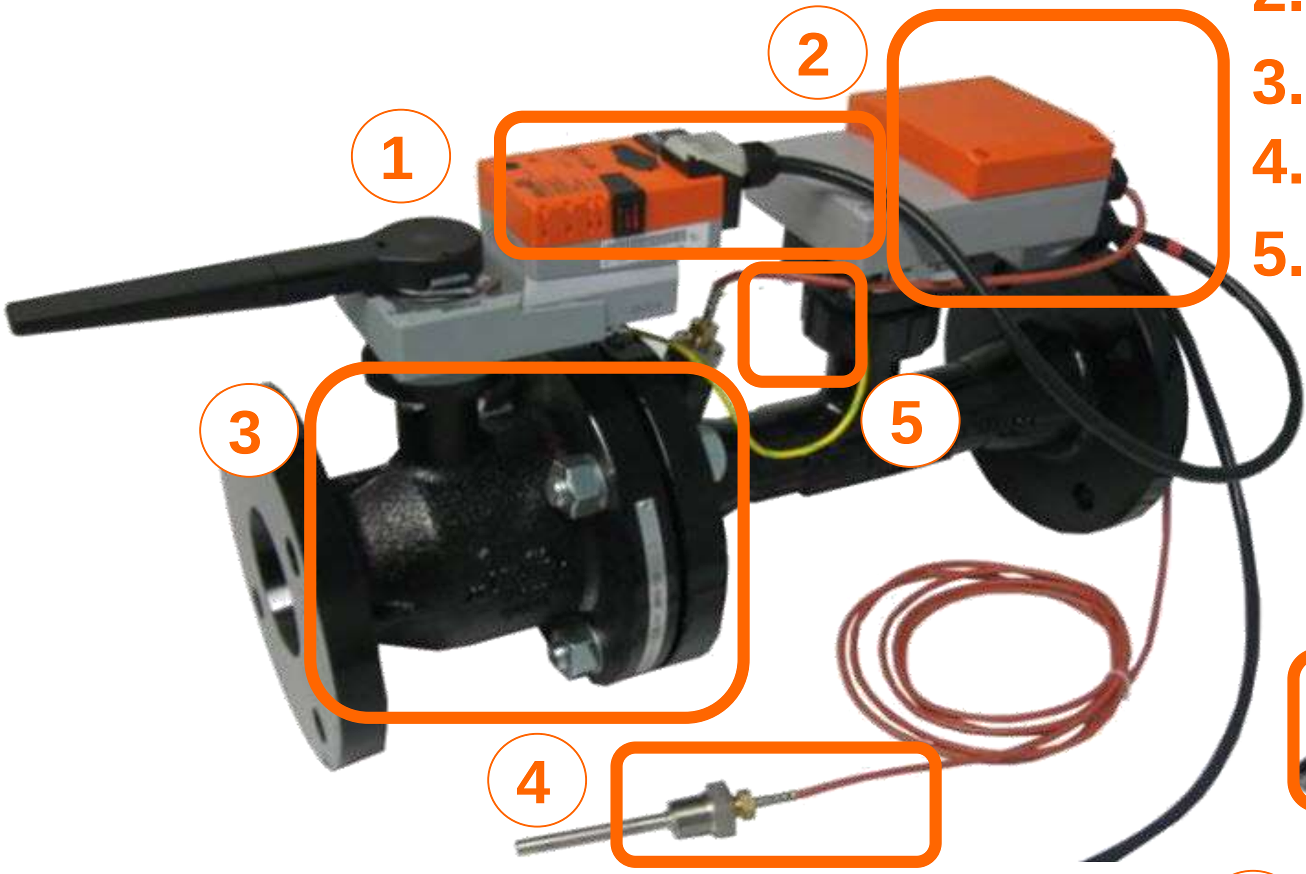
Electronic Pressure Independent Valve
Flow Meter Balancing

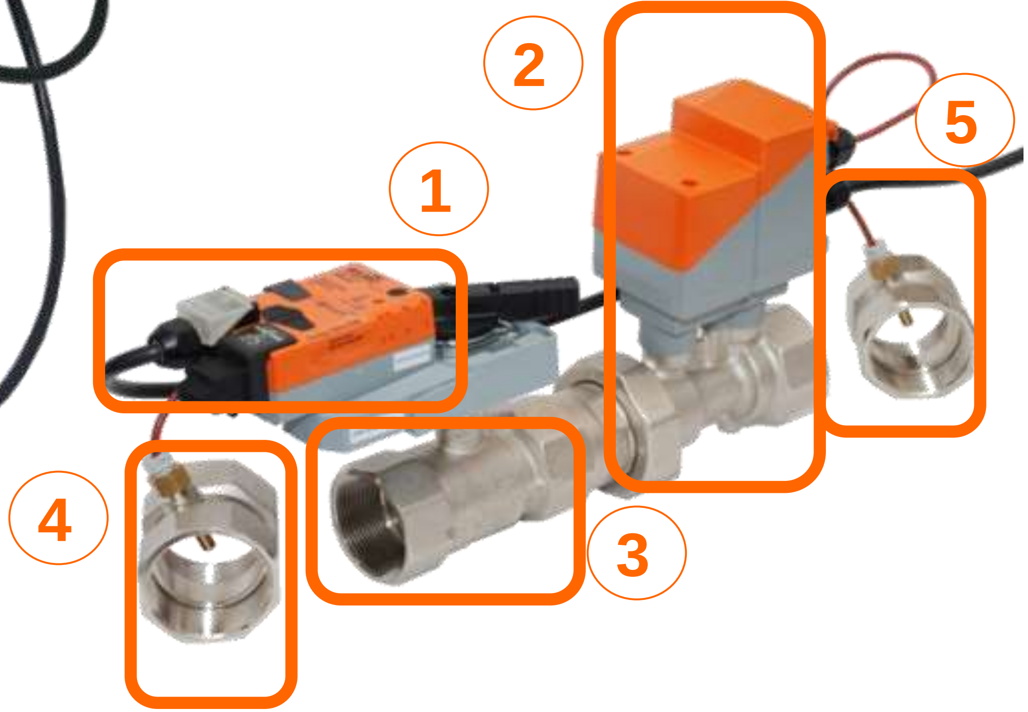
1/2’’– 6”, 1.65 thru 713 GPM



Pressure Independent
Delta T Control + Flow/Btu Meter

1. Actuator
2. Flow Sensor (±2% tolerance)
3. CCV Valve
4. Temperature Sensor (remote)
5. Temperature Sensor





Library Case Study

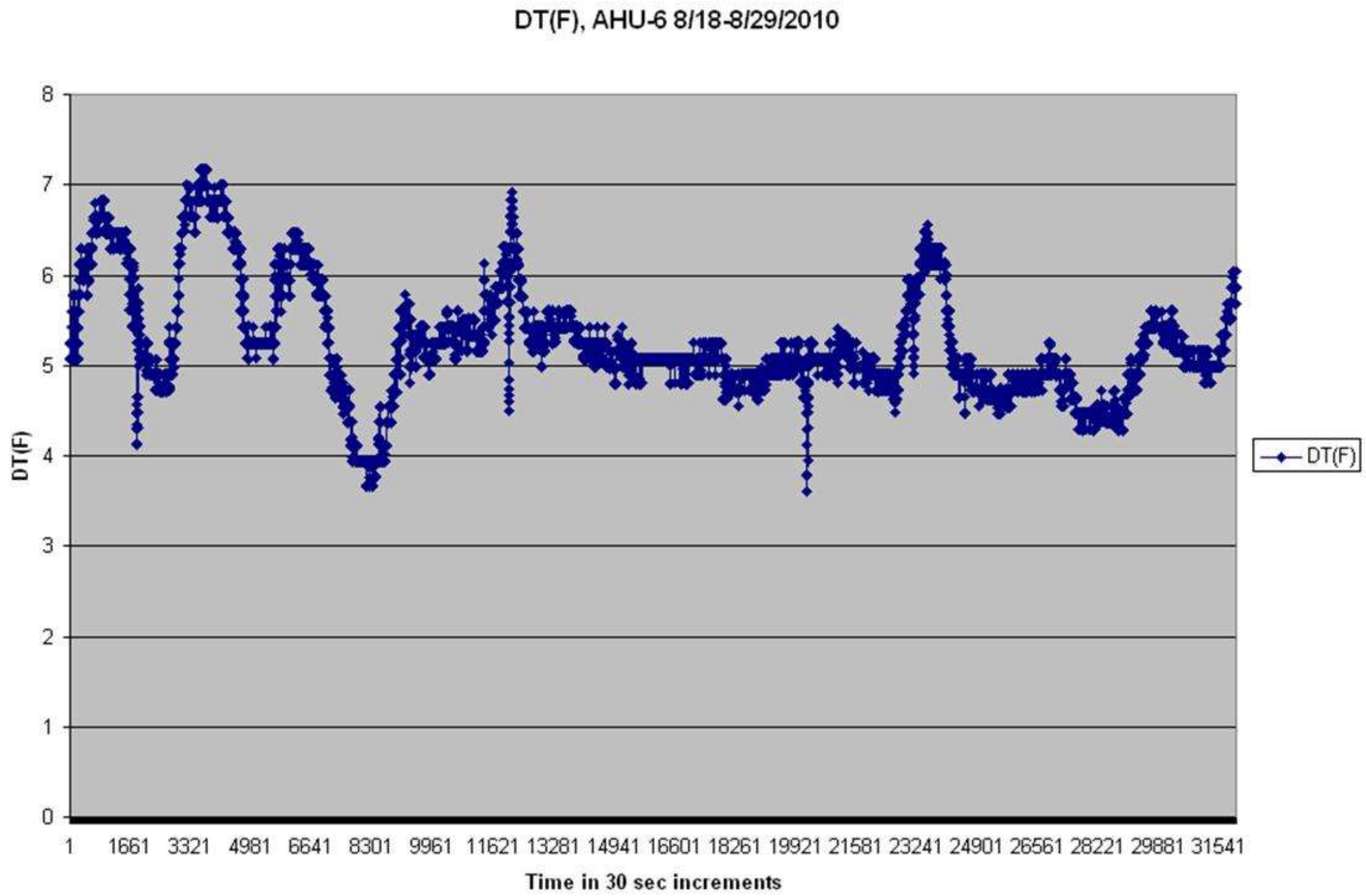
Case Study Issues

- Coil Delta T reported as 6 Degree F
- Over pumping
- Low Delta T Syndrome at Chiller Plant

6 AHU units, 153,000 sq-ft

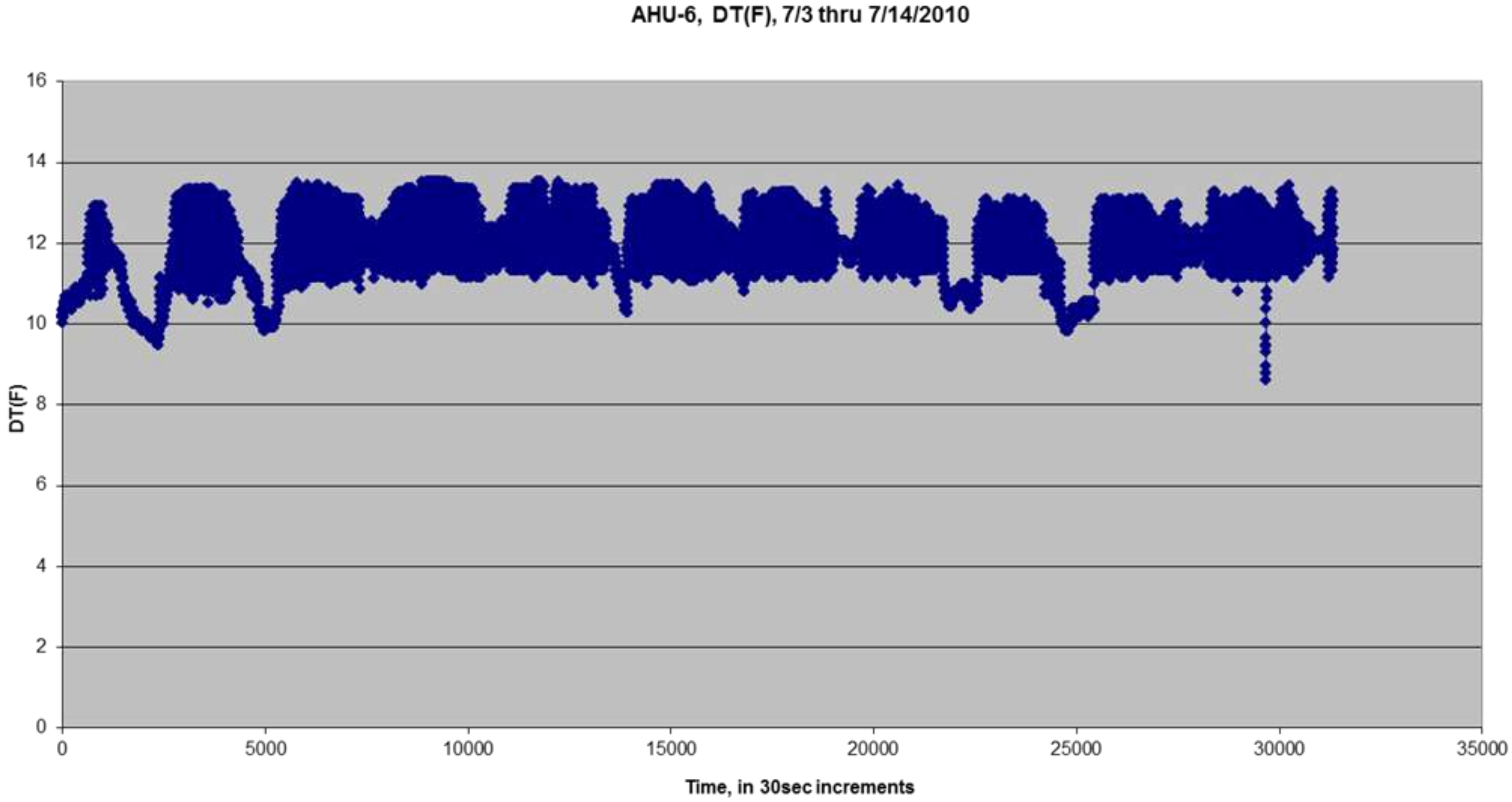
Case Study

AHU-6, CHW Delta T with Belimo SL System Globe Valve test Delta T control deactivated.



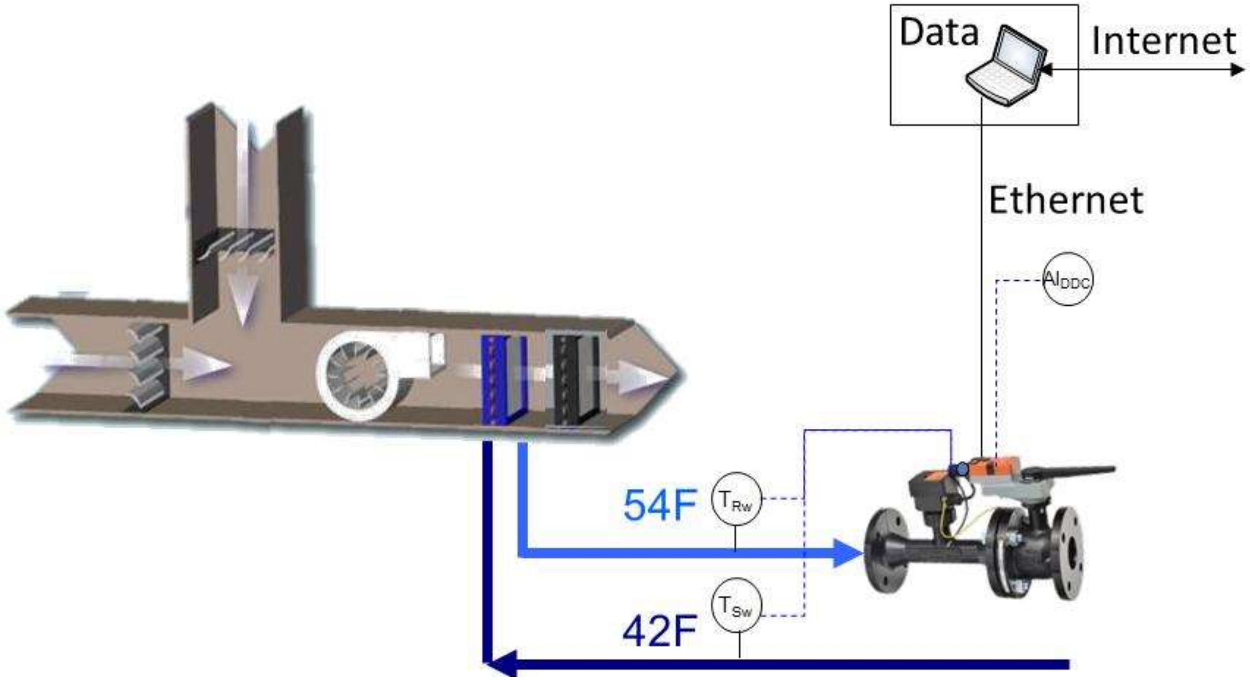
Case Study

AHU-6, CHW Delta T with Delta T control active Globe Valve test.



Case Study Setup

- **5 Energy Valves**
- **1 Tandem PICCV with Delta T Manager**
- **Chilled Water is designed to run through a coil at a designed temperature drop to supply air conditioned cooling air and to de-humidify. i.e. Water delta T=12 degrees F.**



Case Study
Library Whole Building Results

2011 vs. 2010 Flow

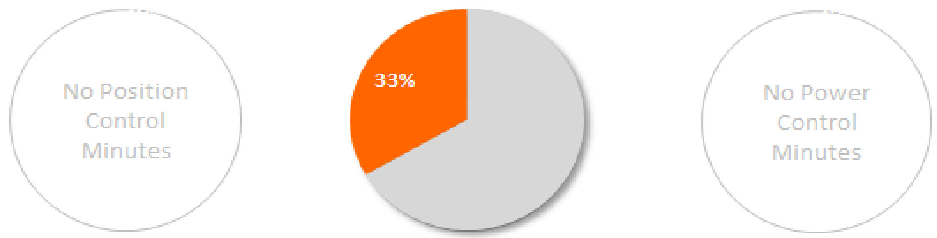
- 8/9-10/9 2010 6.15 F DT
- 8/9-10/9 2011 12.14 F DT
- From whole building meters, Metering data PI archive
- Tonsx24/GPM= Weighted Average Delta T

6 AHU units – 153,000 sq-ft

NJ Pharmaceutical AHU 1, July 13, 2016

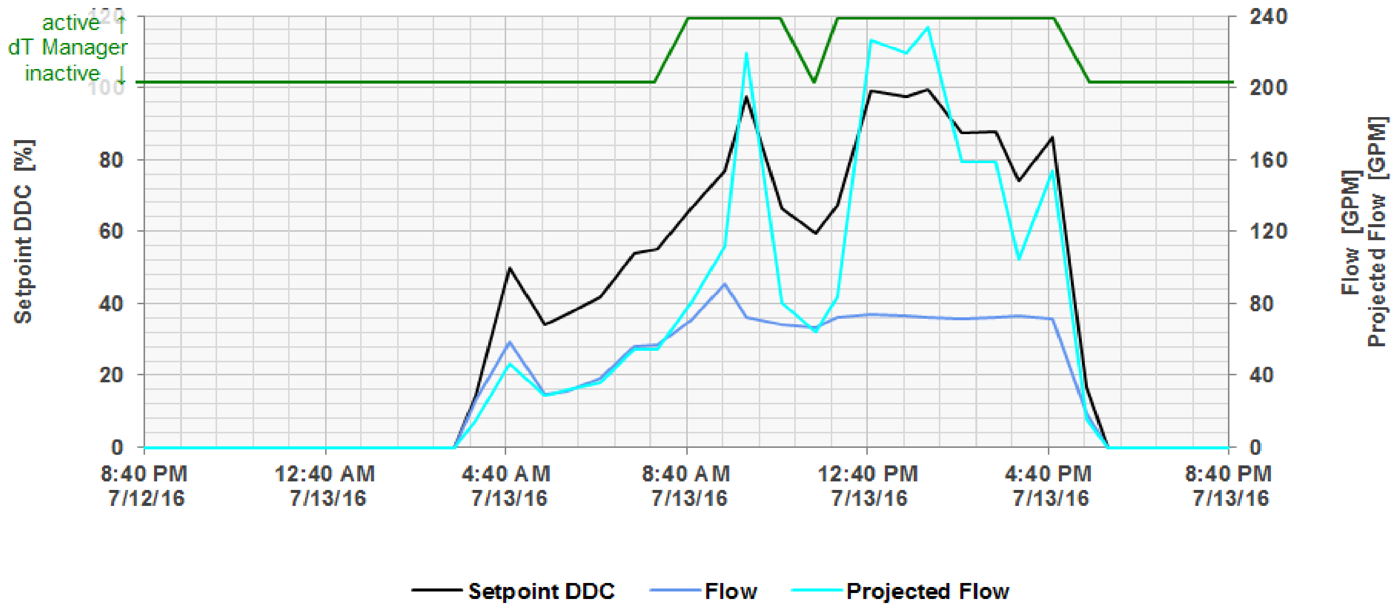
Standby | Active

Position Control DeltaT Manager Active | Flow Control DeltaT Manager Active | Power Control DeltaT Manager Active Status



Delta T - Manager Active Status	Position Control		Flow Control		Power Control	
	Above	Below	Above	Below	Above	Below
Specify Delta T Threshold	12	12	17	17	12	12
Minutes Above or Below			200	1240		
Percent Above or Below			14%	86%		

POWER AND CONTROL



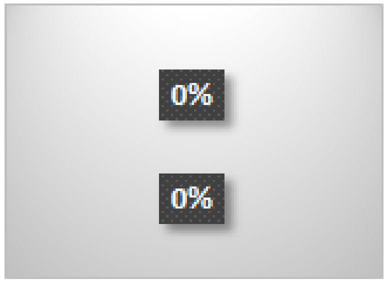
The DeltaT Manager has been set to ON for 1440 minutes out of the 1 Day of captured data.

The DeltaT Manager status is:

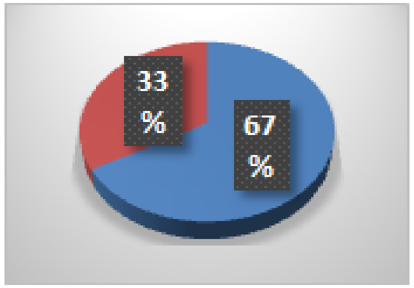
	Standby	Active	Active %
Position Control:	0	0	0%
Flow Control:	960	480	33%
Power Control:	0	0	0%

The Active % by Control Modes indicates the amount of time the DeltaT Manager has taken control over the DDC signal to prevent over flow and low coil DeltaT.

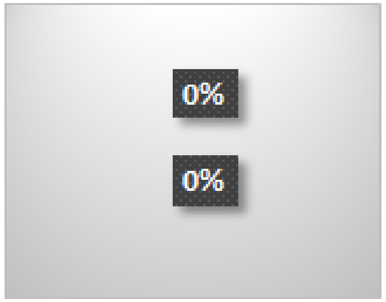
Position Control DeltaT Manager Active Status



Flow Control DeltaT Manager Active Status



Power Control DeltaT Manager Active Status



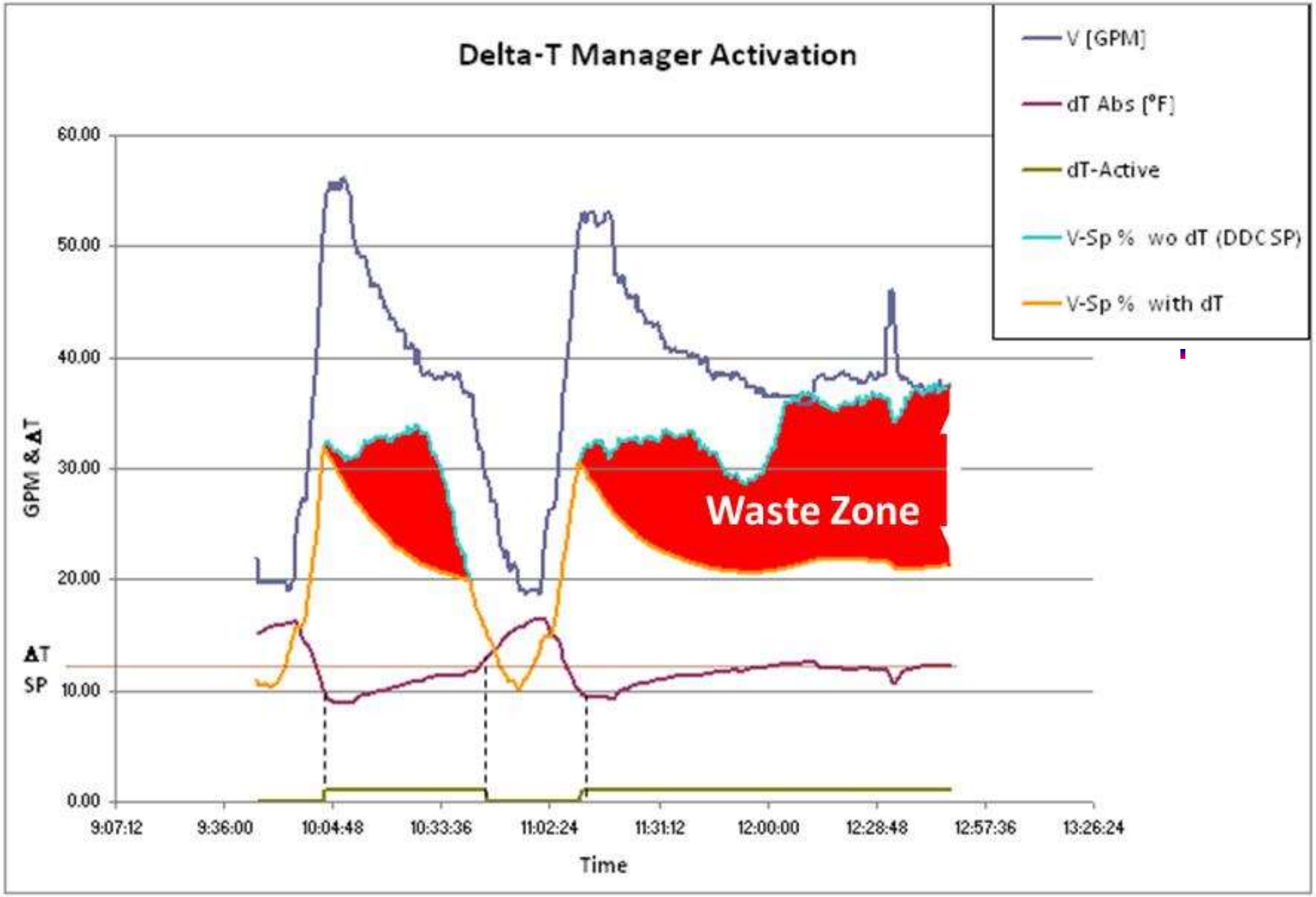
SAVINGS CALCULATOR

The projected flow rate thru the valve if the DeltaT Manager was not enabled would be 152.44 GPM which would have produced 73,170.04 GPM of water compared to the Actual amount of 35,248.80 GPM which is a savings of 52% or 37,921.24 GPM.

New Definitions

- **Power Saturation Point**
  - **Point beyond which coil cannot yield additional heat transfer regardless of increased flow.**
- **Waste Zone**
  - **Range beyond the “Power Saturation Point.”**

Energy Valve Delta T Manager Operation



DDC SIGNAL

Chilled & Hot Water Coil design
Energy Valve/Delta T Manager
Coils function per design GPM and Delta T

FAN SECTIONS													
UNIT NO	LOCATION	SERVES	VENTILATION DES.	VENTILATION MIN.	CFM	EXT. SP	WHEEL TYPE	FAN RPM	MAX BHP	ELECTRICAL HP	ELECTRICAL VOLTS	ELECTRICAL PH	ELECTRICAL RPM
AHU-1	BSMT WEST MER	WEST LEVEL A & 1	7,000	1,247	19,733	2.00"	PLENUM	1718	26.7	(2) 15	480	3	1750
AHU-2	BSMT WEST MER	CLASSROOM A17	854	111	2,560	1.25"	PLENUM	3852	2.77	5	480	3	1750
AHU-3	BSMT WEST MER	FORUM	2,432	168	4,825	2.00"	PLENUM	2350	7.10	7.5	480	3	1750
AHU-4	BSMT WEST MER	SOUTH ATRIUM	6,585	589	8,860	2.00"	PLENUM	2218	11.28	(2) 7.5	480	3	1200
AHU-5	BSMT EAST MER	EAST	1,100	106	6,525	2.00"	PLENUM	2181	7.88	10	480	3	1750
AHU-6	BSMT EAST MER	CLASSROOM A71	887	109	2543	1.25"	PLENUM	2810	2.98	5	480	3	3600
AHU-7	PENTHOUSE	CHILLED BEAMS	19,200	8,231	22,183	2.00"	PLENUM	2475	51.35	(3) 20	480	3	1750
AHU-8	PENTHOUSE	WEST LEVEL 2 & 3	6,300	1,372	19.875	2.00"	PLENUM	1696	25.57	(2) 15	480	3	1750
AHU-9	PENTHOUSE	CHILLED BEAMS	8,000	3,872	10,402	2.00"	PLENUM	2539	16.79	(2) 10	480	3	1200
AHU-10	PENTHOUSE	AHU-5,6, & 8	7,687	7,687	7,687	2.00"	PLENUM	2303	8.39	(2) 5	480	3	1750

UNIT NO	HOT WATER COIL CAP MBH	AIR DATA EAT	AIR DATA LAT	WATER DATA EWT	WATER DATA LWT	WATER DATA GPM	VEL FPM	AIR PD	WATER PD	ROWS FINS	CHILLED WATER COIL CAP MBH	AIR DATA EAT	AIR DATA LAT	WATER DATA EWT	WATER DATA LWT	WATER DATA GPM	VEL FPM	AIR PD	WATER PD	ROWS FINS
AHU-1											511.4/468.2	76.1/62.9F	54.5/54.1F	44	60	63.7	512	0.611"	3.83'	6/113 FPF
AHU-2	69.4	50.0	75.0	140	120	7.0	480	0.114"	0.22'	1/135 FPF	96.3/75.6	76.9/63.2F	50.0/49.9F	44	60	12.0	480	1.006"	6.67'	8/141 FPF
AHU-3	133.5	50.0	75.0	140	120	13.4	438	0.079"	0.69'	1/112 FPF	223.8/147.6	77.2/65.5F	50.0/49.9F	44	60	29.7	417	0.844"	4.59'	8/140 FPF
AHU-4	240.2	50.0	75.0	140	120	24.1	368	0.051"	1.31'	1/98 FPF	502.9/293.5	79.0/68.0F	49.0/48.9F	44	59	62.7	368	0.680"	11.25'	8/133 FPF
AHU-5											167.8/149.8	75.4/62.73F	54.5/53.9F	44	60	20.1	497	0.542"	2.25'	6/103 FPF
AHU-6	69.0	50.0	75.0	140	120	6.91	477	0.085"	0.84'	1/123 FPF	96.1/76.0	77.2/63.3F	50.0/49.9F	44	60	11.97	477	0.989"	17.61'	8/140 FPF
AHU-7	513.7	45.0	55.0	140	120	80.6	514.6	0.090"	1.42'	1/123 FPF	1328.4/ 689.9	77.5/69.0F	50.4/50.3F	44	60	(2)106.7	489.6	1.12"	20.68'	10/139 FPF
AHU-8											522.9/475.9	78.1/62.9F	54.3/53.9F	44	60	65.2	516	0.637"	3.99'	8/115 FPF
AHU-9	270.0	50.0	75.0	140	120	27.0	514.6	0.090"	1.42'	1/123 FPF	750.4 329.8	78.8/72.8F	50.4/50.3F	44	60	93.5	363	0.649"	9.32'	8/116 FPF
AHU-10																				

Chiller Plant & Pumps Run as Designed
VFD at Min Flow per Demand

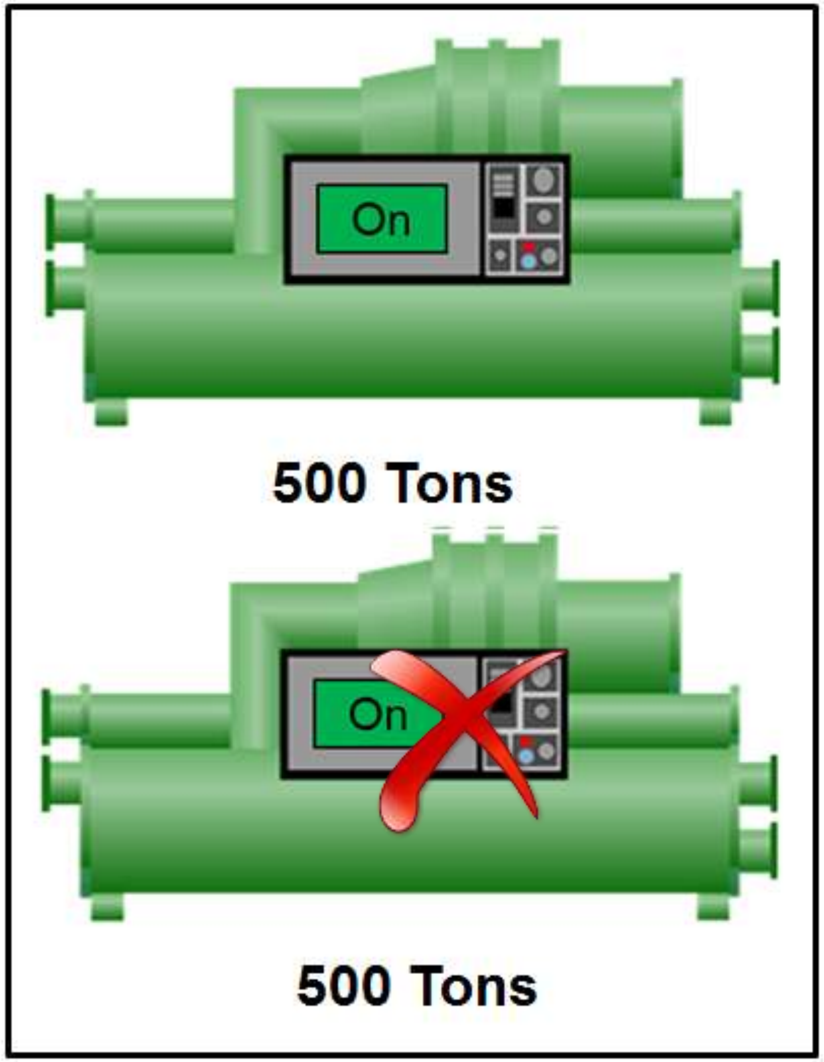
Plant Efficiency

- **Chillers**
  - Plant is more efficient at Design ΔT than at low ΔT
  - Low DT (high flows) can cause Improper staging

$$GPM = \frac{Tons \times 24}{\Delta T}$$

$$GPM = \frac{500 \times 24}{12} = 1{,}000$$

$$GPM = \frac{500 \times 24}{8} \cancel{= 1{,}500}$$



Energy Valve Overview

1	**Actuator** Webserver, data logger, BACnet, Modbus, MP-Bus, Cloud capability
2	**Electronic Flow Meter** True Flow, Wet calibrated
3	**Temperature Sensors** Platinum based RTD for supply and return, allowing BTU measurement
4	**Logic** Delta T Management and flow meter, pressure independent balancing

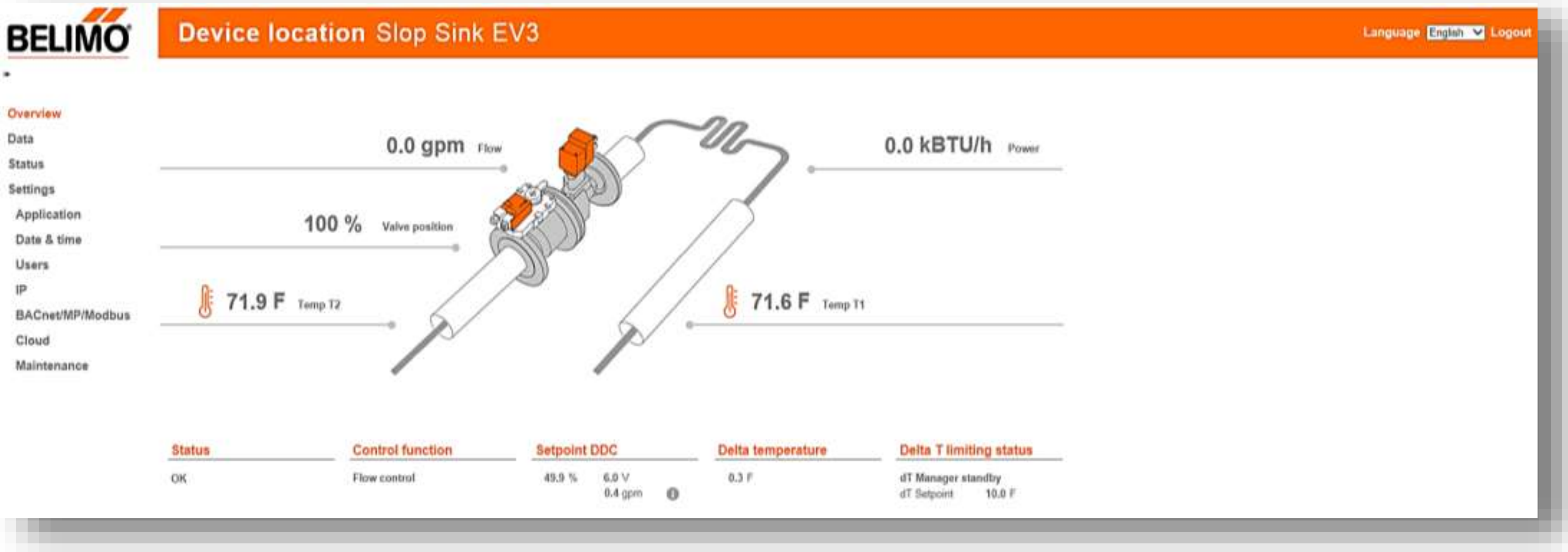
Measure, Observe, Record and Trend Performance Data

Data Acquisition

The Energy Valve will trend and store:

- Flow
- Delta T
- Energy Output
- Power Output
- Totalized Energy
- Calculate Savings

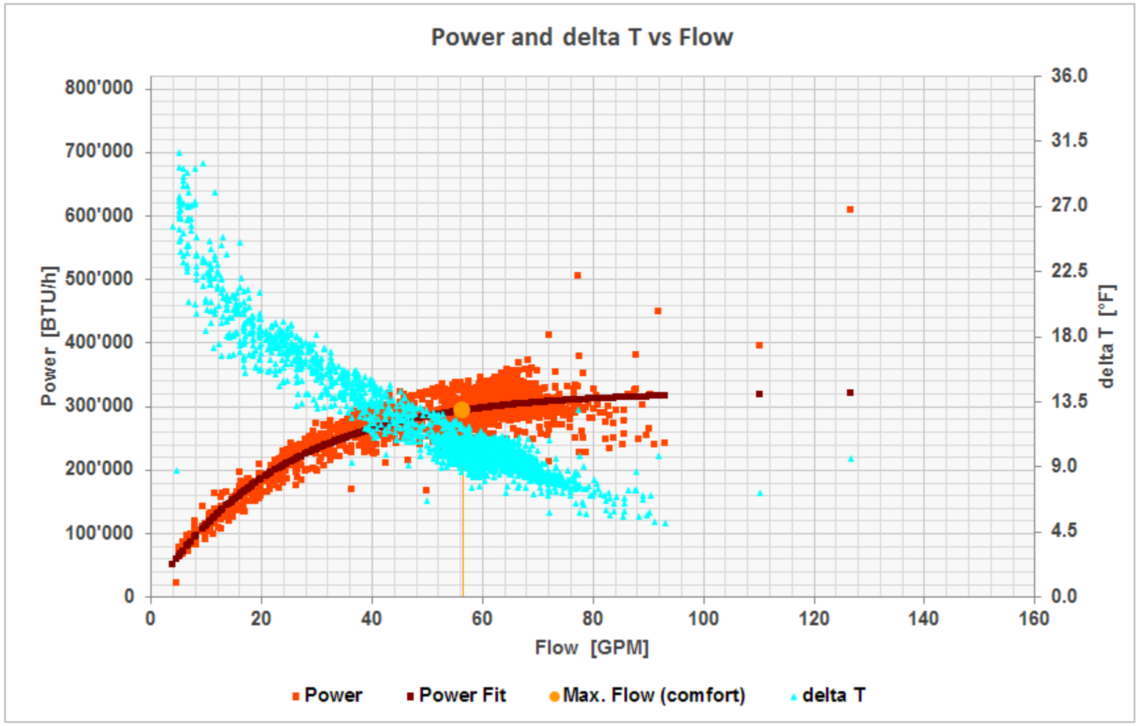
Data Acquisition
Live information



Data Acquisition
Data Export and the Excel Tool

Energy Valve

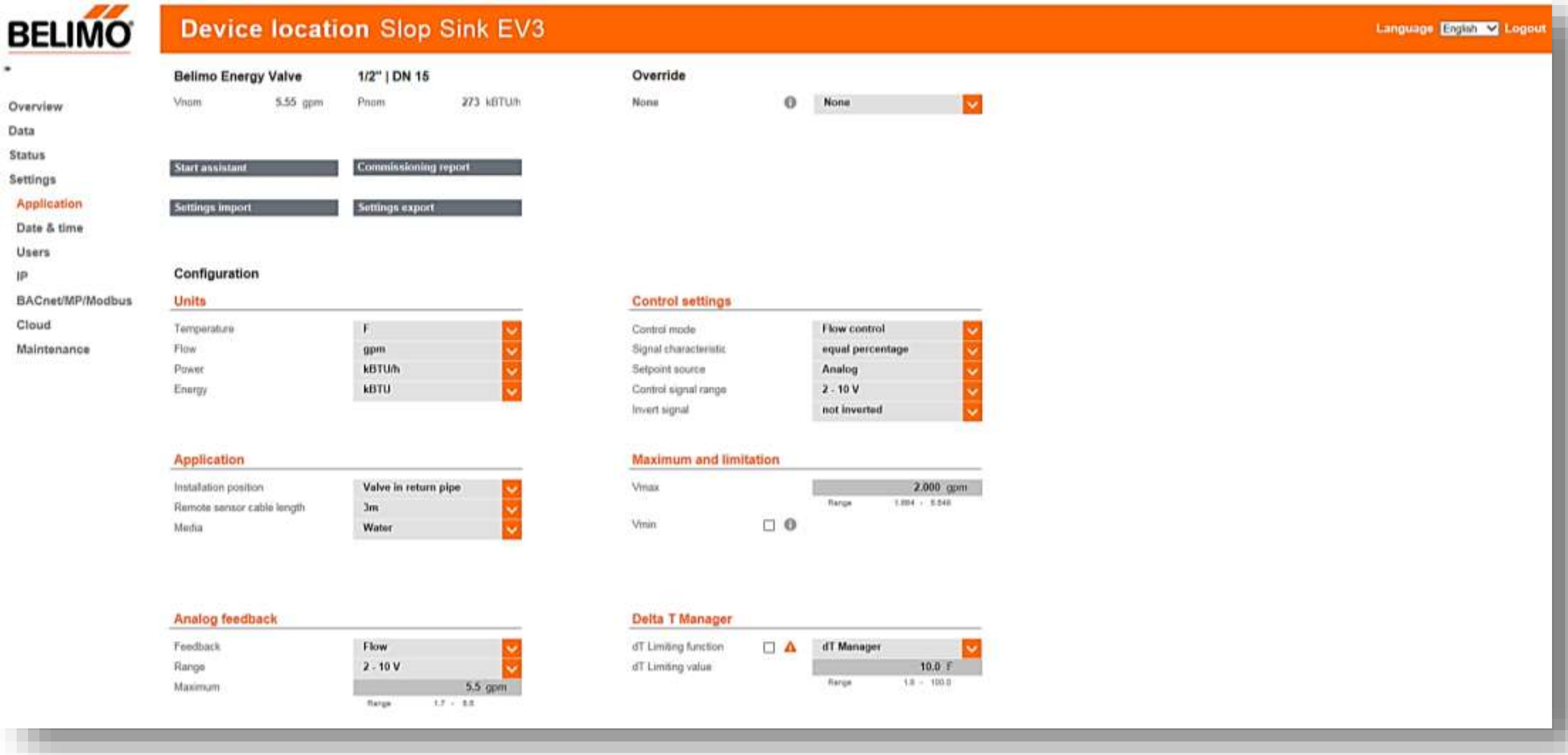
- Data Logging and Storage
- Up to 13 Months of Data
- Export to .csv file format
- Charts, Graphs, Trending



Excel Tool

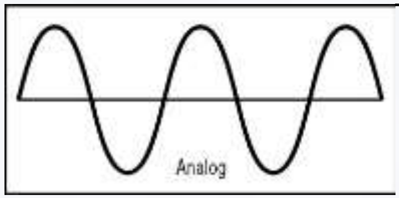
- Import .csv in to Excel Tool
- Power Curves
- Charts, Graphs, Trending

Optimization
Settings

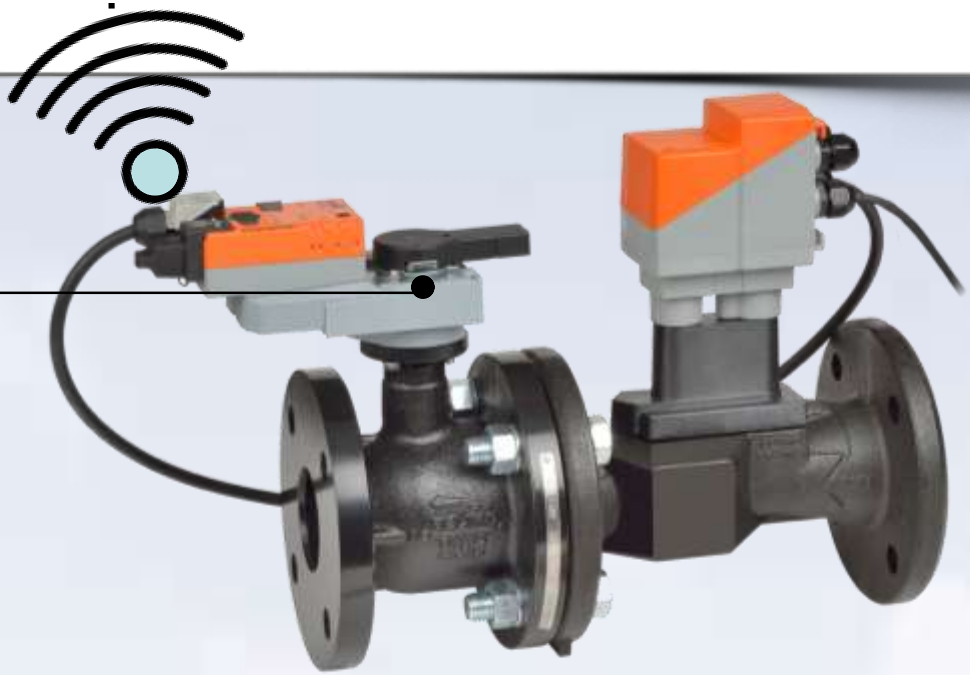


Enhanced Communication
Unlike Any Actuator on the Market

ANALOG

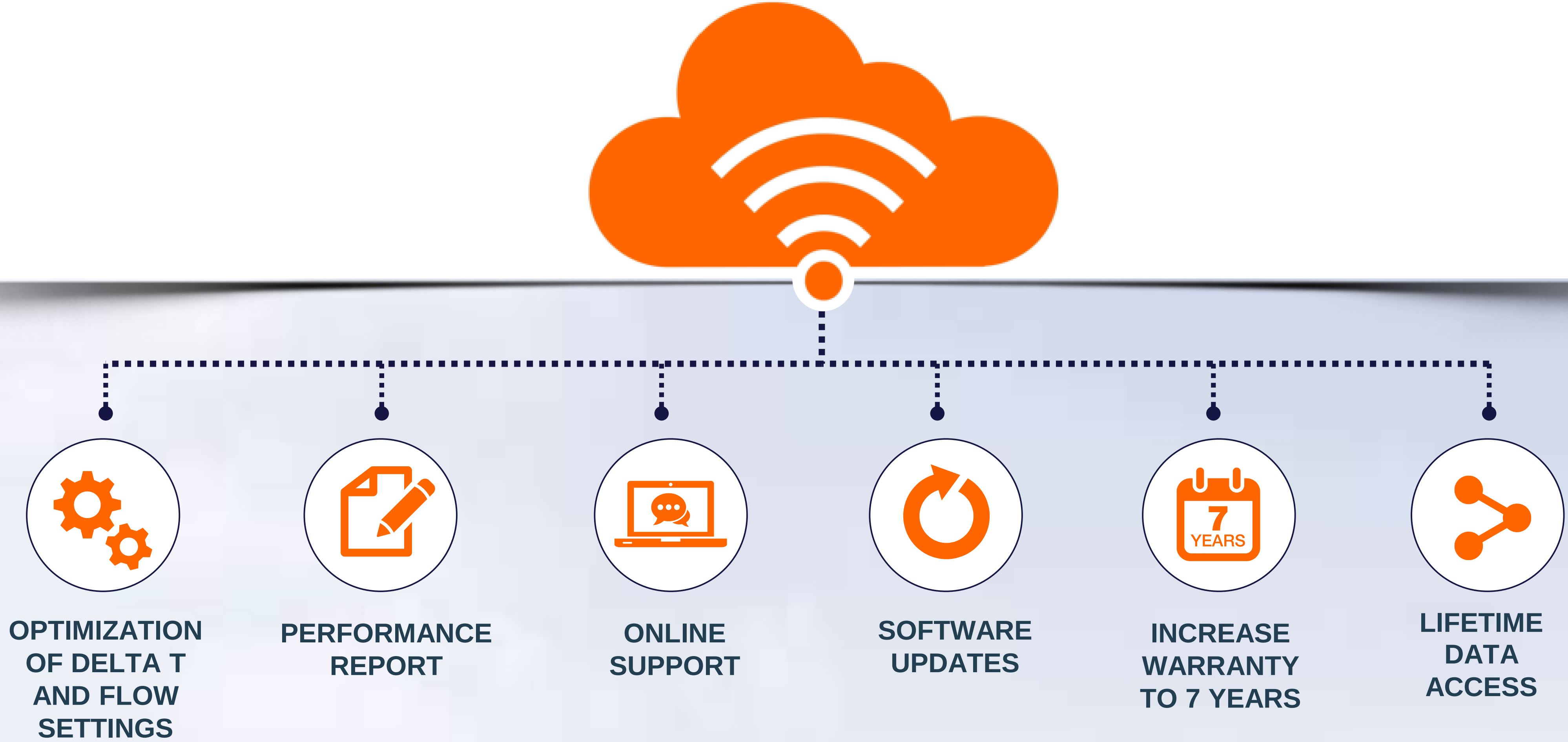


- 2-10 VDC
- 0.5 -10 VDC

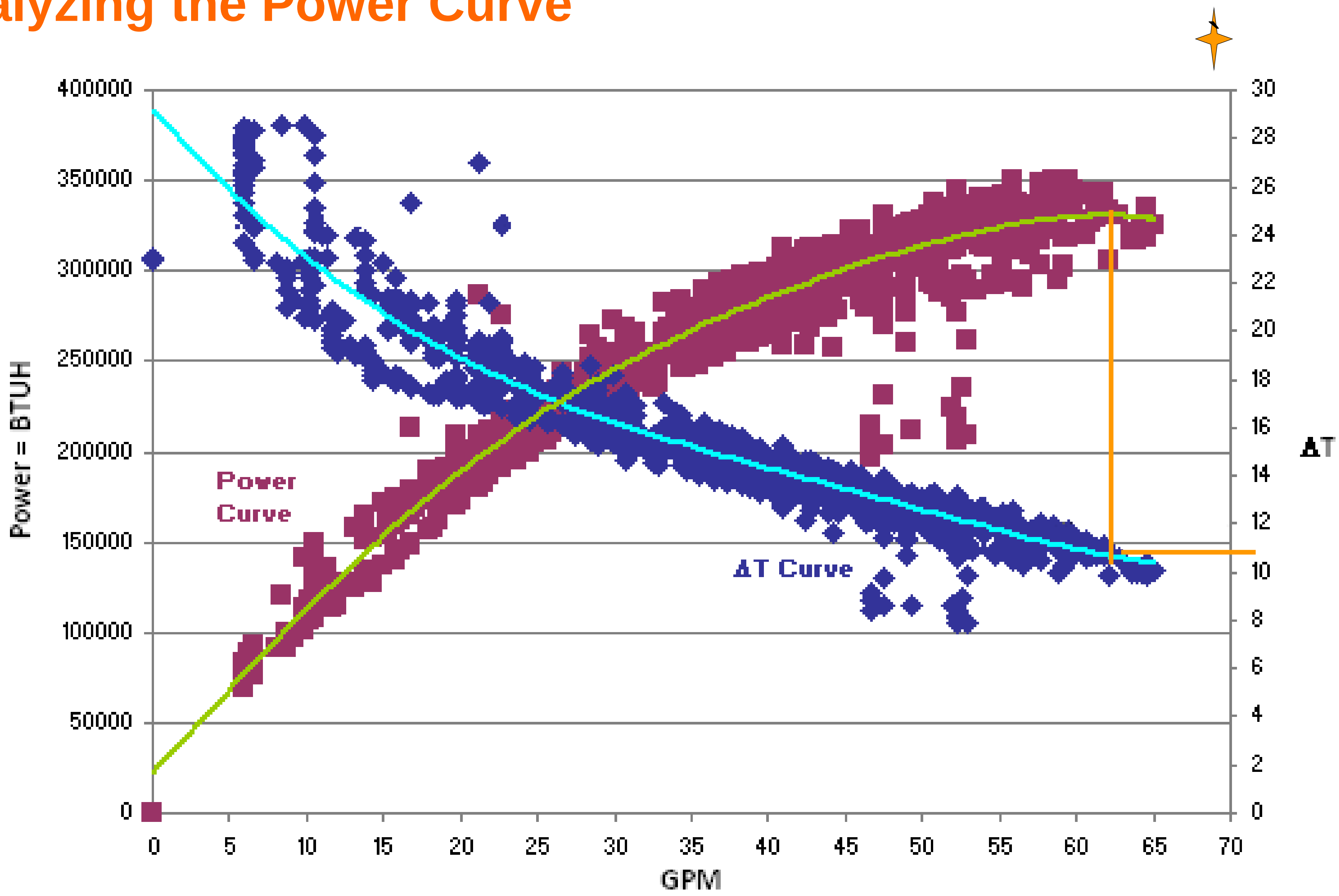


Energy Valve 3.0 Cloud Services

Advanced Optimization with Multiple Benefits



Data Analysis
Analyzing the Power Curve

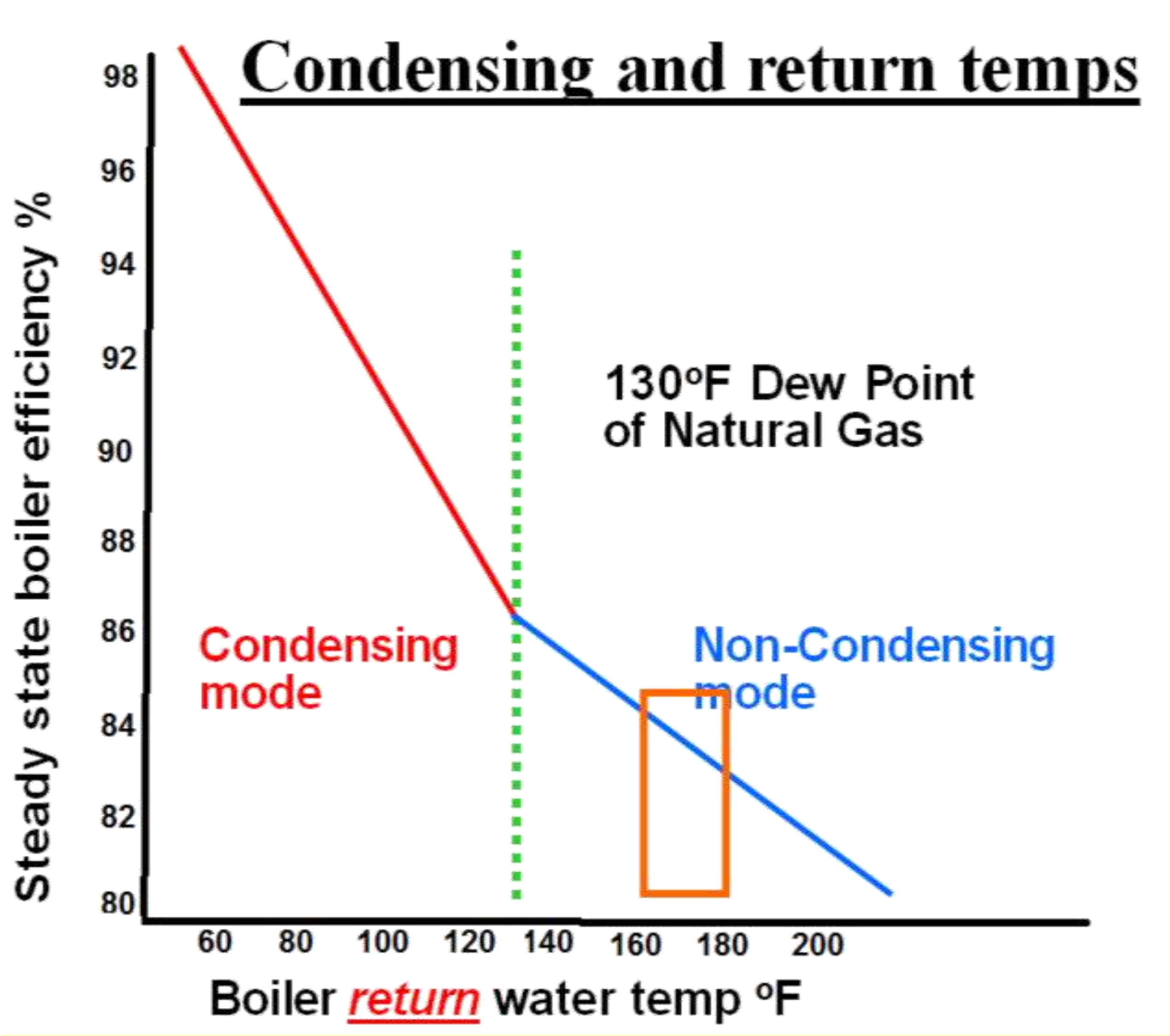


Parameterization Tools
Hand Held Device (ZTH-US)

- Quick Programming
- Quick Reconfiguration
- Fast Commissioning
- Local Display

Condensing Boiler Applications Delta T Manager

Set Water Delta T per design



Before Adding Pumps, Chillers & Boilers

Correct Water Delta T

- **A plant designed at 500 tons of cooling & 12 Degree Delta T can produce 1000 GPM. At 12 degrees, 40% load, Flow=400 GPM.**
  At 6 degree, 40% load, Flow=800 GPM
- **Annual cost at 6 degrees=$24,203, at 12 degrees $9,730.00**

Pump Design Factor			100%
Design Chilled Water Distribution dT			12

Load [%]	Time [%]	Time [h]	Flow [GPM]	Head [ft]	Power [HP]
100	5.0	385	1000	150	50.5
80	40.0	3078	800	96	25.9
60	30.0	2309	600	54	10.9
40	15.0	1154	400	30	4.0
20	10.0	770	200	30	2.0
10	0.0	0	200	30	2.0

Pump costs	**$9,730**
Annual Gal.	290879947
Avg GPM	630
Energy [kWh]	97301

Chilled Water Distribution Flow at Delta T [F]:	6

Load [%]	Time [%]	Time [h]	Flow [GPM]	Head [ft]	Power [HP]
100	5.0	385	1000	150	50.5
80	40.0	3078	1000	150	50.5
60	30.0	2309	1000	150	50.5
40	15.0	1154	800	96	25.9
20	10.0	770	400	30	4.0

	Pump costs
Pump costs	**$24,203**
Annual Gal.	420159924
Avg GPM	910
Energy [kWh]	242035

OUT OF WATER

Consequences of Over Pumping

- **Additional chillers and associated equipment are utilized**
  - Chillers run at part load and operated at a higher energy rate per ton of cooling
- **Diminished equipment life and increased maintenance needs**
- **Unstable control**
- **Compromised occupant comfort**

Eliminating the High Cost of Over Pumping
Thank You