Operating Engineers Seminar 2016

Jeff Volovsek jeff.volovsek@districtenergy.com 651.925.8169

Bob Ford bob.ford@districtenergy.com 651.925.8128

Quick facts on District Energy

- District Energy Facts:
  - Largest hot water system in North America
  - Started in 1983
  - Serving 199 customers
  - 4 new customers added in 2016
  - Over 21 miles of 250 degree hot water piping.
  - Primary energy source is waste heat from a wood-fired combined heat and power system generating electricity and capturing heat for downtown. The wood fuel is from waste sources like tree trimmings and habitat restoration.

Quick facts on District Cooling

- District Cooling Facts:
  - Started in 1993 serving 8 customers
  - Serving 114 customers
  - 3 new customers added in 2016
  - 6 miles of 42 deg temperature, schedule 40 piping
  - Peak loads in excess of 24,000 tons of cooling

Today's topics:

- Troubleshooting your system
- Chilled water Delta T
- Hot water efficiency
- Water treatment
- Questions

How should my system run?

Mechanical Schedules

AIR HANDLER UNIT SCHEDULE

COOLING COIL DATA									
TOTAL CAPACITY (BTU/H)	COOLING (GPM)	WATER P.D. (FT HD)	WATER TEMP (F)		ENTERING AIR		LEAVING AIR		
			ENT	LVG	DB (F)	WB (F)	DB (F)	WB (F)	
570,153	76.7	35.3	44	60	77.4	64.5	55.6	53.9	

HEATING COIL DATA						
WATER TEMP		ENT TEMP		LVG TEMP		HEATING WATER (GPM)
ENT	LVG	DB	WB	DB	WB	
167	140	45	—	65.5	—	24.4

PLATE HEAT EXCHANGER SCHEDULE

TAG	LOCATION	SOURCE SIDE				LOAD SIDE				
		EWT (F)	LWT (F)	GPM	PRESSURE DROP (PSI)	EWT (F)	LWT (F)	GPM	PRESSURE DROP (PSI)	MA
HX-1	BUILDING HEAT EXCHANGER BASEMENT	250	150	17.7	4.35	150	180	57	4.35	
HX-2	BUILDING COOLING WATER BASEMENT	42	56	87.6	4.35	60	46	84	4.35	
HX-3	BUILDING DOMESTIC	150	80	12.3	3.46	50	120	12	3.172	
HX-4	AHU HOT WATER COIL	177	147	31.4	4.35	140	167	36	4.35	

FAN COIL UNIT SCHEDULE

COOLING COIL DATA											
EADB (F)	EAWB	LAWB (F)	TOTAL (MBH)	SENSIBLE (MBH)	EWT (F)	LWT (F)	FLUID TYPE	GPM	COIL ROWS	EWT (F)	LWT (F)
85	60	51.17	11572	12038	54	69.42	35% PG	1.5	6 ROW	–	--

Mechanical Submittals

Scope of Supply

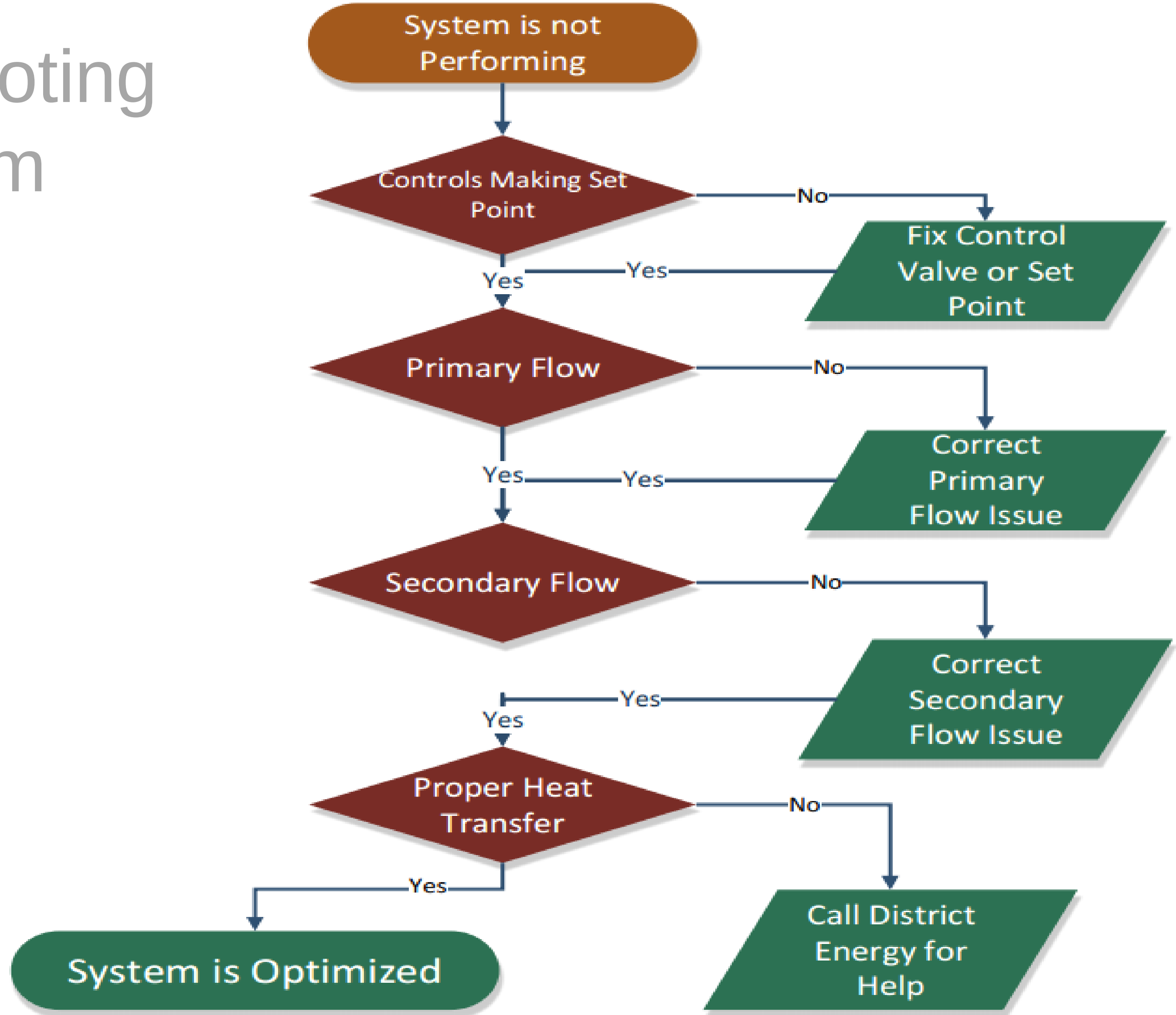
Product Description | Brazed Plate Heat Exchanger
Quantity: 1 | Tag: HX-1

Alfa Laval Model CB110-30H T09 Brazed Plate HX

Hot Side:	Cold Side:
Water	Water
20.9 GPM	57.0 GPM
250 °F Inlet Temp	147 °F Inle
157 °F Outlet Temp	180 °F Out
1.74 psi Pressure Drop	11.4 psi Pr

Tag	26000 CFM	32000 CFM
Air flow (SCFM)	26000	32000
Total capacity (MBH)	946.2	1065.8
Sensible capacity (MBH)	608.9	706.8
Entering dry bulb (°F)	77.0	77.0
Entering wet bulb (°F)	67.0	67.0
Leaving dry bulb (°F)	55.7	56.9
Leaving wet bulb (°F)	55.4	56.5
Face velocity (ft/min)	427	525
Air pressure drop (in of water)	0.52	0.69
Air fouling factor (h·ft²·°F/Btu)	0.00000	0.00000
Fluid	W	W
Entering fluid temp. (°F)	44.0	44.0
Leaving fluid temp. (°F)	58.0	58.0
Fluid flow rate (GPM)	134.7	151.8
Fluid velocity (ft/s)	4.08	4.60

Troubleshooting Your System



Troubleshooting: Step 1

- Is the heat exchange device set point correct and is the device making that set point?
  - Yes: Move to step 2
  - No: Investigate operation of the valve
    - Operate valve to full open
    - Operate valve to ensure complete close off

Troubleshooting: Step 2

- Is the flow correct on the primary (District Energy) side?
    - Use the District Energy meter to determine how much primary flow is being used.
    - If there are multiple devices using flow, manually isolate each device to observe its flow.
  - Yes: Move on to step 3:
  - No: Look for increased pressure drop across heat exchanger, strainer(s), or complex sections of piping.

Troubleshooting: Step 3

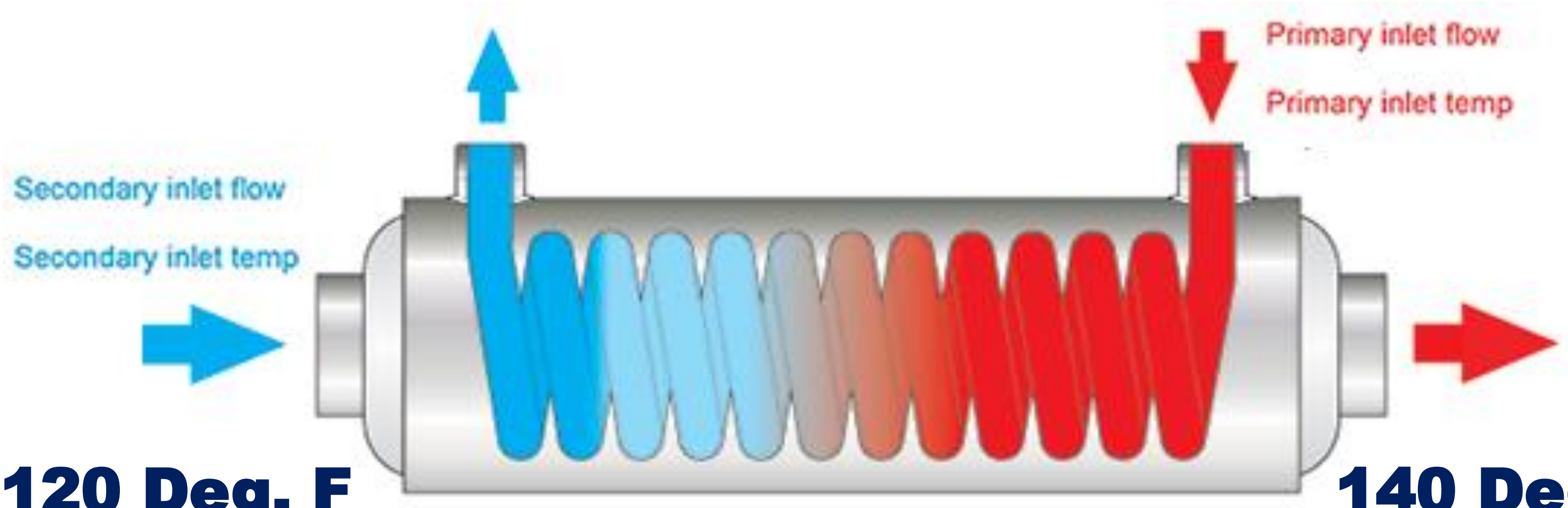
- Is the flow correct on the secondary (building loop) side?

Approximating Flow with Temperatures

District Energy flow is read to be 100 GPM

150 Deg. F

250 Deg. F



120 Deg. F

140 Deg. F

Pahlen

Approximating Flow with Temperatures

- Supply – Return = Delta T
  - District Side: 250 Deg. F – 150 Deg. F = 100 Deg. F
  - Building Side: 140 Deg. F – 120 Deg. F = 20 Deg. F
- Flow Multiplier

District Side Delta T

  - District Side ÷ Building Side = Flow Multiplier
  - 100 Deg. F ÷ 20 Deg. F = 5

*This analysis works only if there is the same fluid on either side of the heat exchange device.

Approximating Flow with Temperatures

- Secondary Flow = District Energy Meter Flow * Flow Multiplier
- Secondary Flow = 100 GPM * 5
- Secondary Flow is 500 GPM

Troubleshooting: Step 3 cont.

- Is the flow correct on the secondary (building loop) side?
  - Yes: Move on to step 4:
  - No:
    - **Flow is too low**: Look for increased pressure drop across heat exchanger, strainers, or complex sections of piping. Also look at pump input energy (Amps) as an indicator to how hard the pump is working.
    - **Flow is too high**: Look for unbalanced loads, three-valves or bypasses, and flow when devices are not supposed to be in operation.

Troubleshooting: Step 4

- Look for proper heat transfer
  - Is the device seeing the proper input temperatures per design?
  - Are the heat transfer surfaces dirty?
- Is the device designed correctly for current use?

Mechanical Schedules Revisited

AIR HANDLER UNIT SCHEDULE

COOLING COIL DATA								
TOTAL CAPACITY (BTU/H)	COOLING (GPM)	WATER P.D. (FT HD)	WATER TEMP (F)		ENTERING AIR		LEAVING AIR	
			ENT	LVG	DB (F)	WB (F)	DB (F)	WB (F)
570,153	76.7	35.3	44	60	77.4	64.5	55.6	53.9

77.4

FAN COIL UNIT SCHEDULE

COOLING COIL DATA											
EADB (F)	EAWB	LAWB (F)	TOTAL (MBH)	SENSIBLE (MBH)	EWT (F)	LWT (F)	FLUID TYPE	GPM	COIL ROWS	EWT (F)	LWT (F)
85	60	51.17	11572	12038	54	69.42	35% PG	1.5	6 ROW	-	--

85

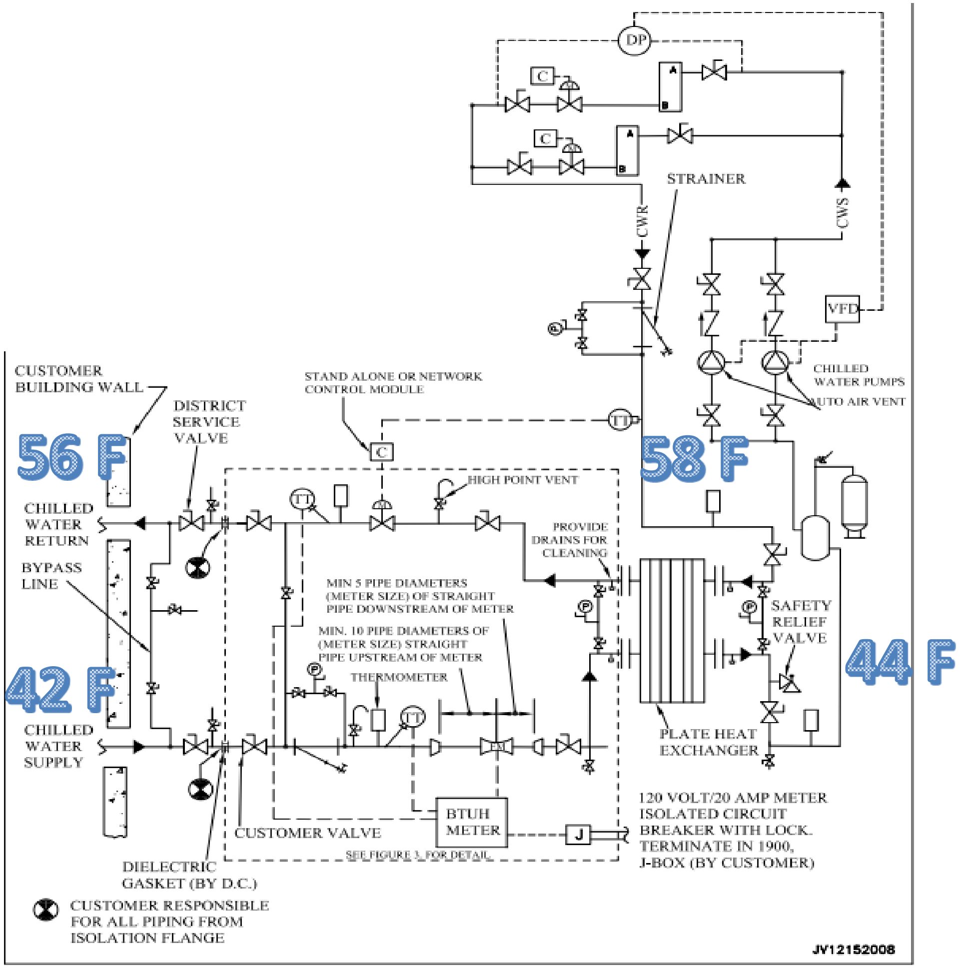
Troubleshooting Summary

- Troubleshooting is as simple as these four steps and as complicated as the engineer of the system made it

- A lot of things can be masked with optimizing controls but there is a point at which replacing the heat exchange devices is the only and best option for better efficiency

Chilled Water Delta T

Chilled Water Delta T



Chilled Water Delta T

$40

- All filtering has its limitations
- Heat transfer surface can be cleaned as part of regular maintenance or preferably it can be done as an as needed basis
- Difference between the two methods is the time it takes for inspection or the devices needed to perform the inspection

$4000

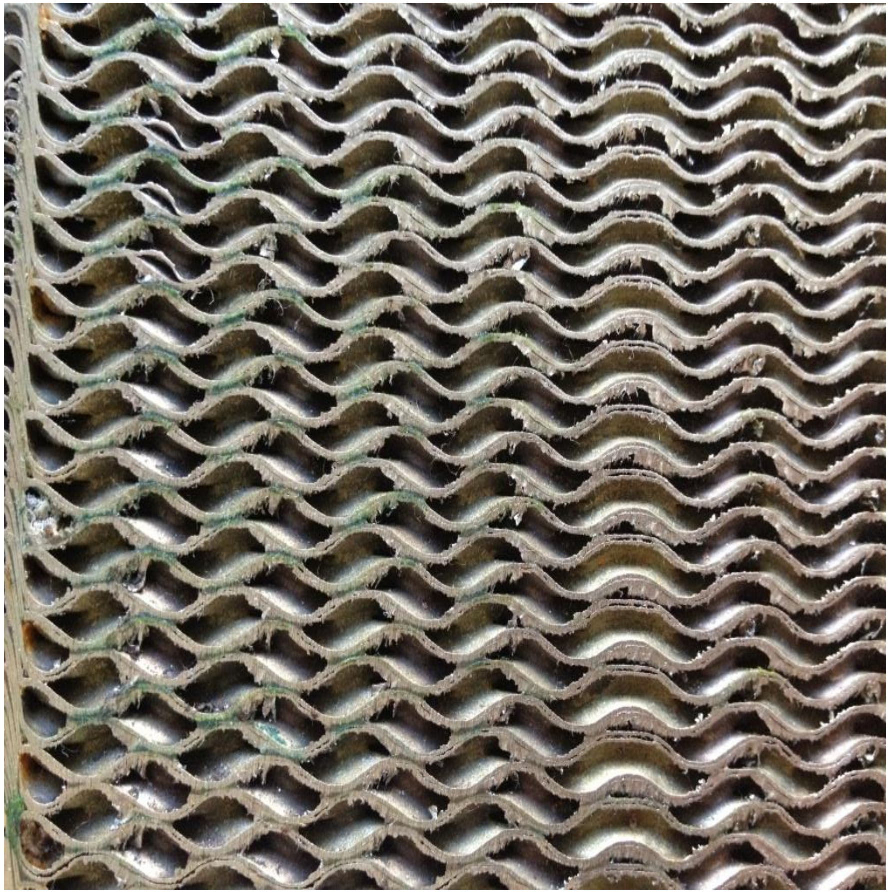
Chilled Water Delta T

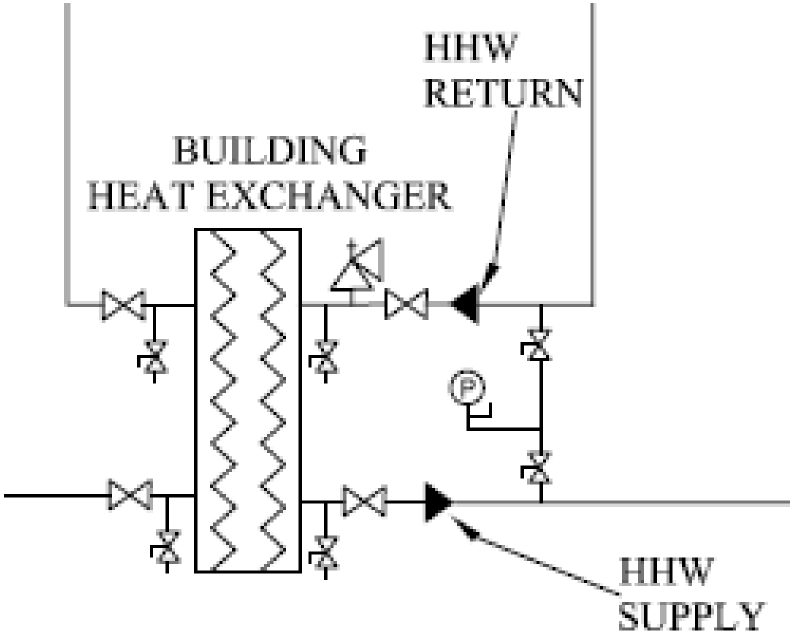
- Leading indicators of poor heat transfer coefficient
  - Visible buildup on heat transfer surface
  - Increase pressure drop across the device
  - Decrease in devices capacity (can't maintain design set point)

Airside Coil Cleaning

- Variable air flow systems don't see large pressure drops during heating or partial cooling loads.
- Want to do inspection to be prepared for this

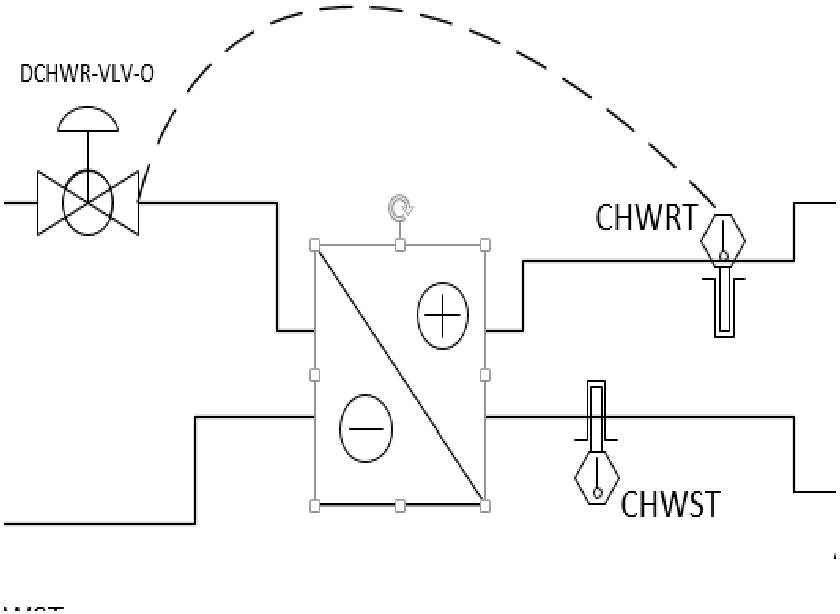
Heat Exchanger Cross Section





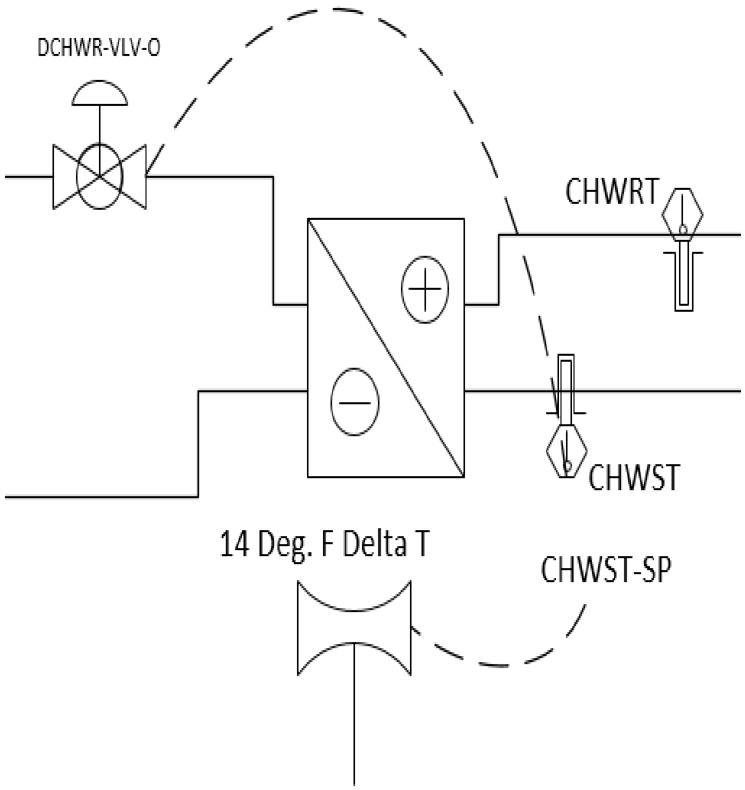
Basic Control for Chilled Water

- Control chilled water primary return valve to maintain 58 Deg. F return temperature from the building



(Advanced) Chilled Water Cascaded Supply Temperature Reset

- Control chilled water primary valve position to maintain chilled water supply set point
- Reset chilled water supply set point based on District Energy differential temperature meter output to maintain 14 Deg. F
- Allows for colder water to the building saving on pumping costs and improving dehumidification



Chilled Water Reynolds Number

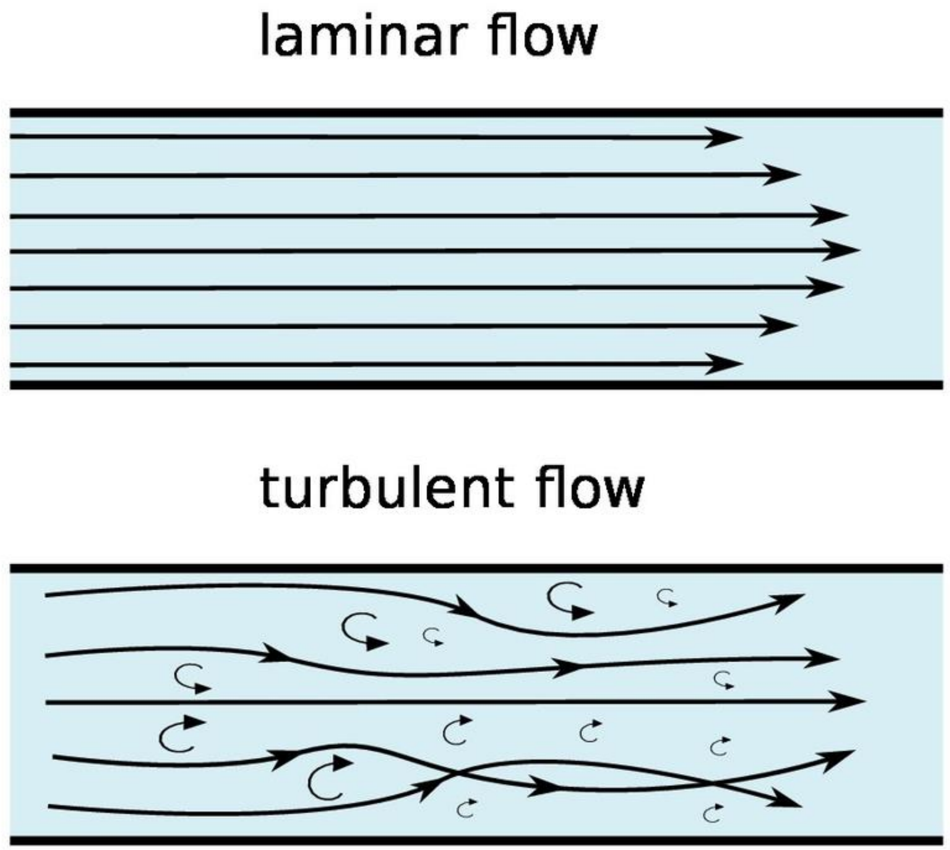
- A dimensionless number that describes the ratio of inertial forces to viscous forces

$$Re = \frac{\rho V D}{\mu}$$

Chilled Water Reynolds Number

- What does that mean!?!

Chilled Water Laminar vs. Turbulent

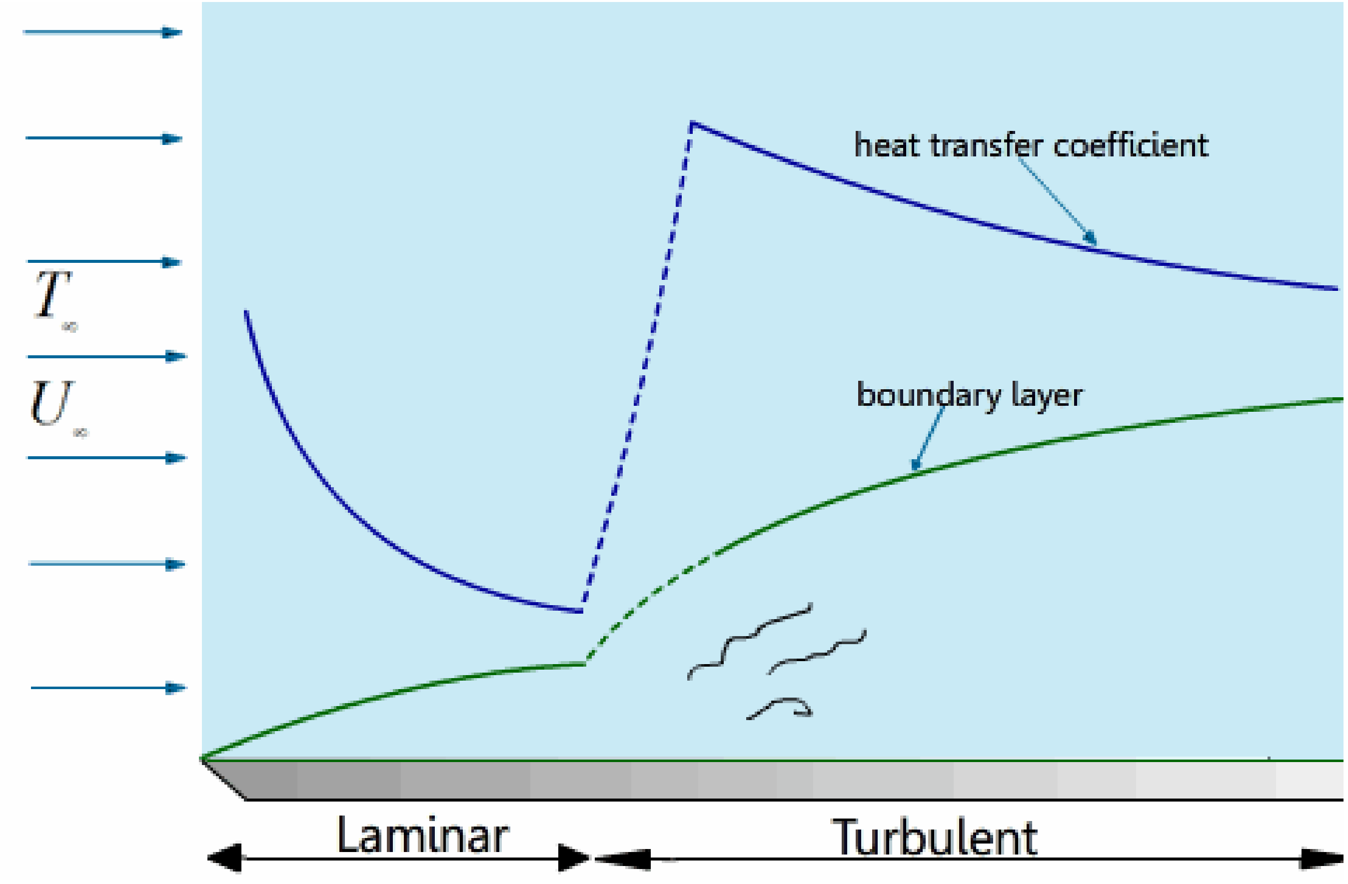


Re < 2000

Re < 4000

OpenFOAM

Why is Turbulent flow important?



Learn Engineering

Chilled Water Turn Down

Problem

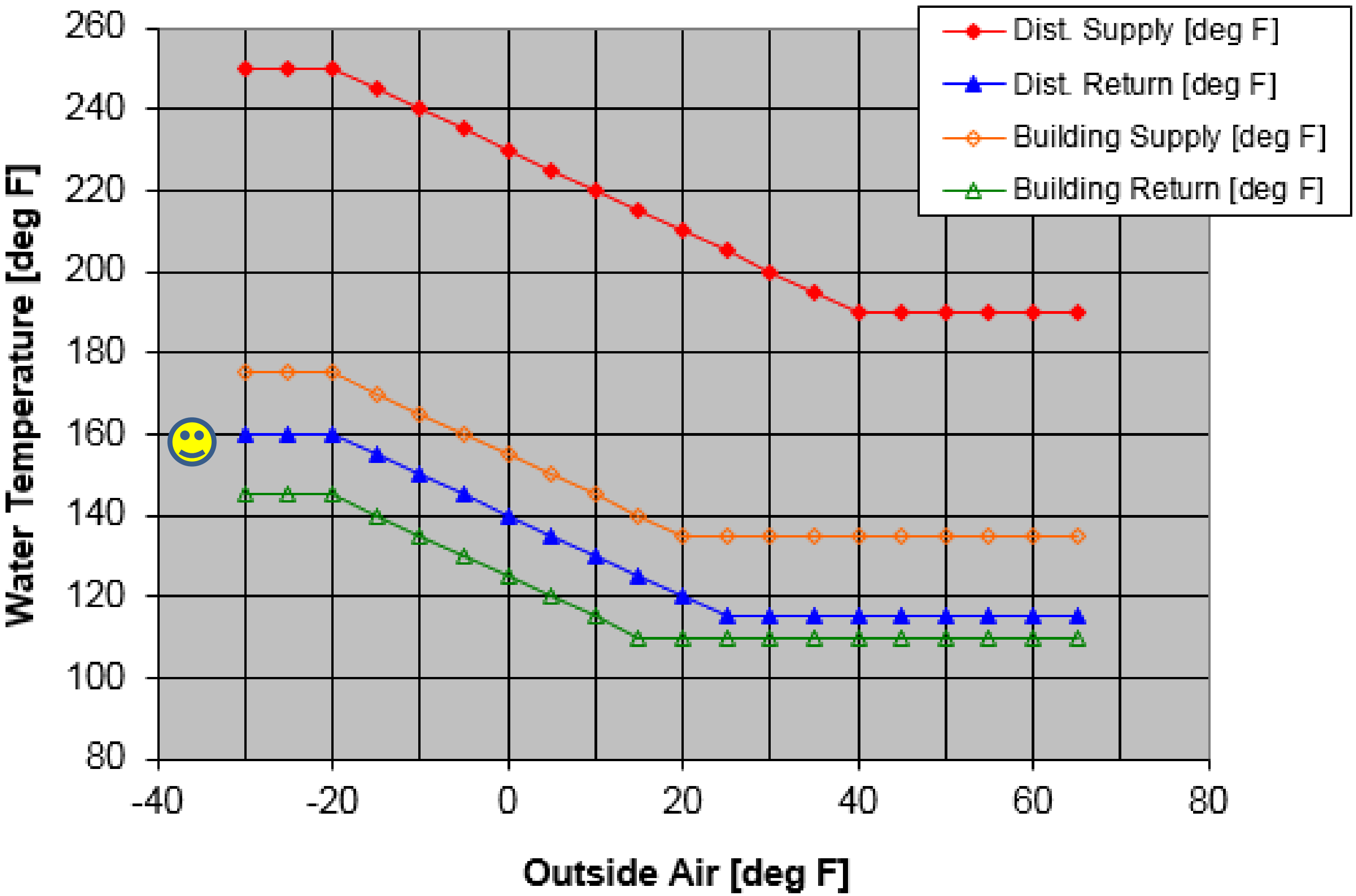
- Control hunting will occur in or below the transitional flow characteristics
- Hard to maintain Delta T at low load

Solution

- Overcome this issue by adding load pump that increases water flow into the Turbulent range.
  - Only run pump at low loads

Hot Water System Efficiency

Hot Water System Efficiency

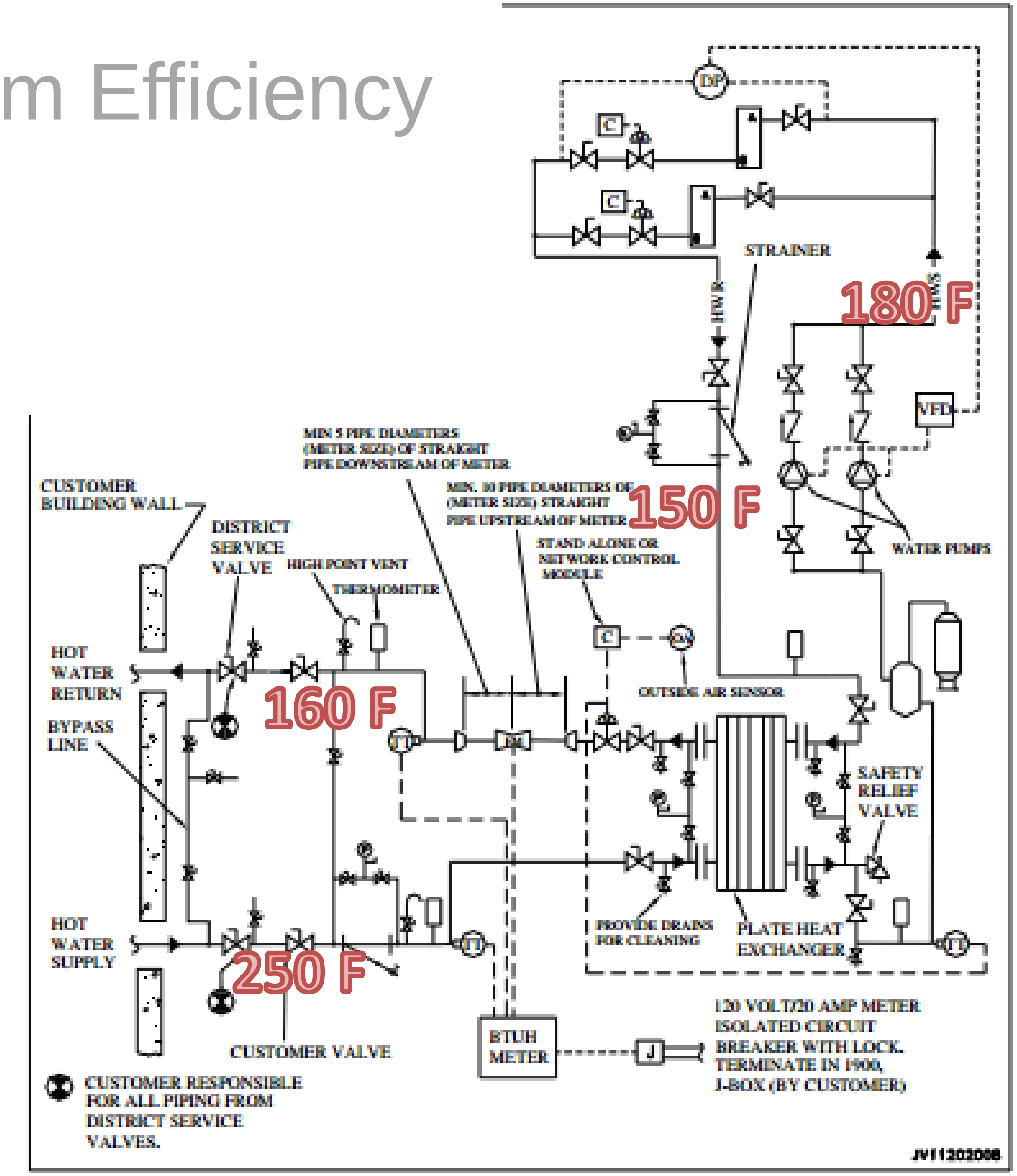


Hot Water System Efficiency

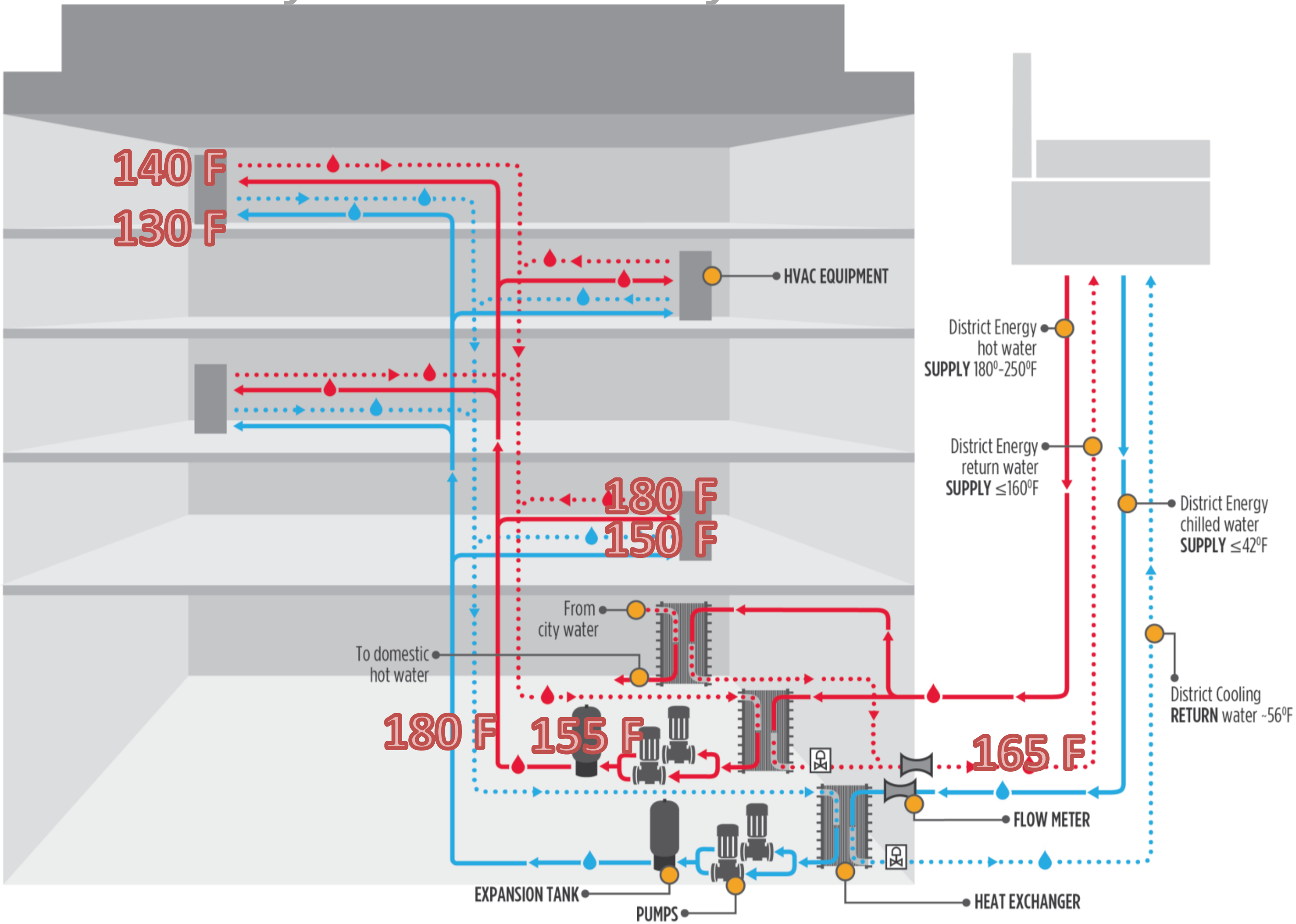
What affects your efficiency?

- Controls/Control Valve
- Heat Transfer Surface Condition
    - Air side fins
    - Water side coils
- Heat Exchanger
- Strainer?

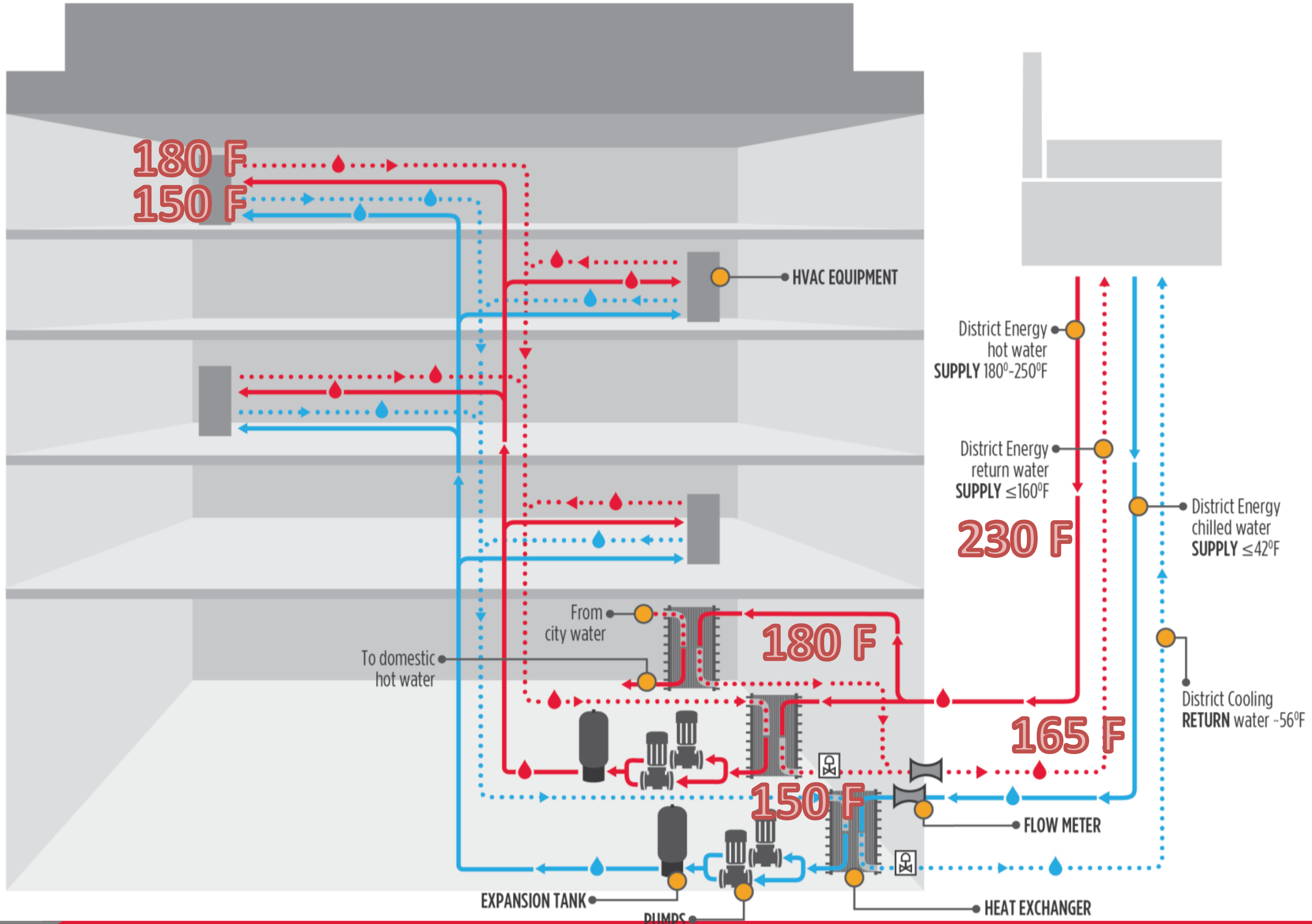
What are my gauges telling me?



Hot Water System Efficiency



Hot Water System Efficiency



Hot Water System Efficiency

$$Q = \frac{m \cdot C_p \cdot (T_s - T_f)}{t}$$

- 1 MMBtu/hr = 22 gpm *500 *(250-160)
- 1 MMBtu/hr = 66 gpm *500*(250-220)

How many extra gallons of hot water to heat a 30,000 sq. ft building in January ?

A. 22,012 gallons
B. 49,989 gallons
C. 533,433 gallons

Hot Water System Efficiency

Is there a cost for this high velocity water?

HEATING SERVICE DETAILS		
Building:		
Energy Usage/Charge	($25.59 per MWh X 55.5 MWh)	$1,420.25
Fuel Adjustment	(($2.49) per MWh X 55.5 MWh)	-$138.20
Demand Charge	($5.27 per kW X 131 kW)	$690.37
Excess Return Temp Charge		$170.90
TOTAL NEW HEATING CHARGES		**$2,143.32**

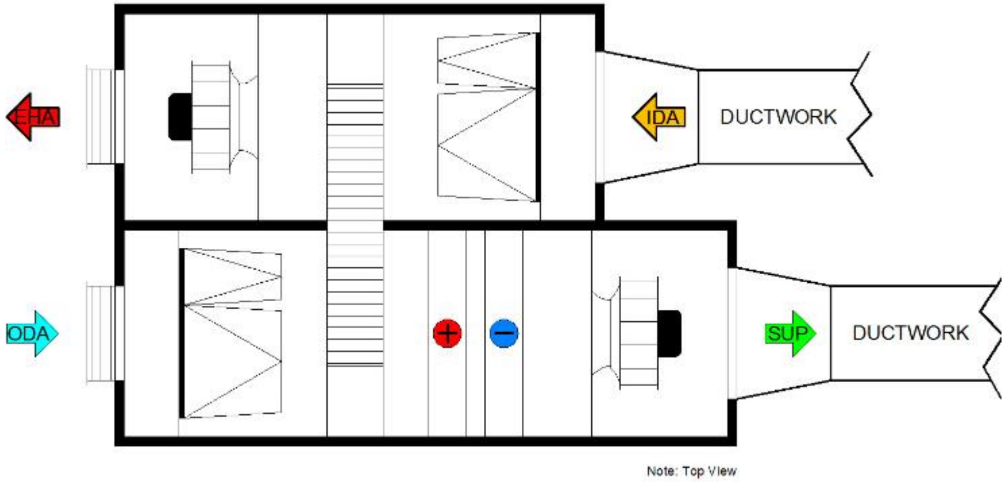
Water Quality

Water Quality and Chemical Treatment

- Hot Water System Loops:
  - Goal is to limit Oxygen that will degrade system.
  - Degraded system leads to scale.
  - Check your building loop once per year.
  - Check your loop more often if loop was altered.
  - Scale lead to rust particulates that circulated and erode pump seals and valve stem packing.

Water Quality and Chemical Treatment

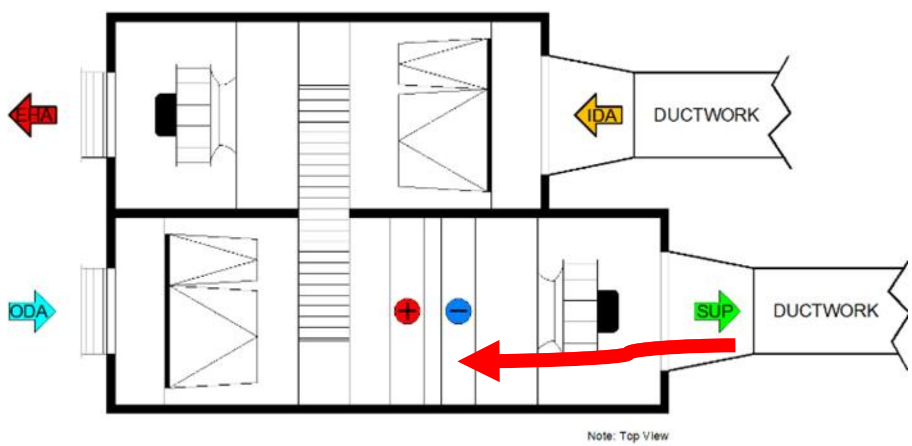
- Direct Connect and HX Systems
  - Isolate vs. Circulate
  - No glycol vs. Glycol
  - SRB's (Sulfur Reducing Bacteria)



ODA - Outdoor Air
SUP - Supply Air
IDA - Indoor Air
EHA - Exhaust Air

Water Quality and Chemical Treatment

- Reliable coil layup



ODA - Outdoor Air
SUP - Supply Air
IDA - Indoor Air
EHA - Exhaust Air

Using system air to blow-dry the tubes of chilled water coils provides a fail-safe winterizing method

By DAVID V. LAROCCA,
Mechanical Maintenance Manager, Yale University School of Medicine, Building Services & Operations Dept., New Haven, Conn.

Winter lay-up for chilled water coils has been a problem for as long as there has been air conditioning. A frozen coil may be so seriously damaged that it must be replaced. Also, as the coil thaws, significant flooding of adjacent areas may result.

Need Help?

Either Jeff or Bob can work with you to figure out what solutions are best for your building

Jeff Volovsek
jeff.volovsek@districtenergy.com
651.925.8169

Bob Ford
bob.ford@districtenergy.com
651.925.8128