2012 Big Ten and Friends Mechanical and Energy Conference

Campus Central Chilled Water Systems

Optimization and Verification Strategies That Work

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Campus Chilled Water Systems

- This presentation is going to focus on optimizing the Chilled water system, not just chilled water plant equipment and configurations. I plan to describe several system features, that we have demonstrated by use, work as advertised. Near the end I will show you the overall effect of implementing these concepts on overall campus energy consumption. We will start at the plant to layout the basic fundamental principles of the optimization of the chilled water system.

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- Chiller Efficiency Concepts
  - Chiller lift-Tower Water Discharge Temp minus Chilled water supply temp
  - For every degree reduction in lift, a constant speed chiller will improve 1-3% efficiency
  - A VFD chiller will improve slightly better
  - A VFD Chiller's only payback is when it experiences many hours at reduced lift and load, it is a penalty at full lift/load.
  - Required Chilled water supply temp is variable.

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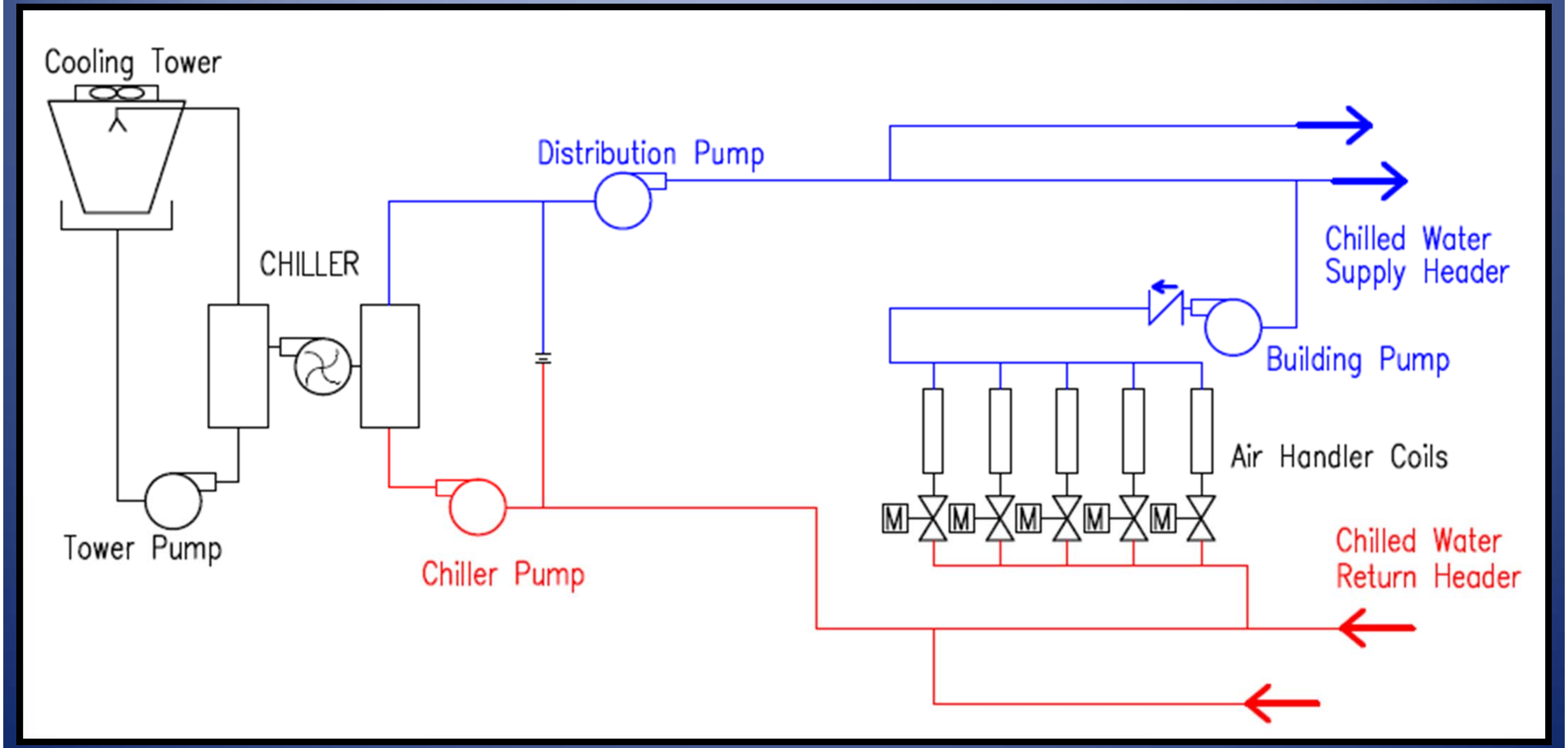
- Chiller Plant system configuration:
- Chillers are now variable flow devices constantly maintained at a flow above minimum flow. Get rid of your decoupling modification.
- Pumps with VFD’s are now variable flow devices.
- In order to save energy, only “pump it” once.
- Pumps increase in efficiency at higher heads and speeds
- It is impossible to increase system head (not flow) more efficiently with two pumps in series than one pump by itself.

CAMPUS CHILLED WATER SYSTEMS



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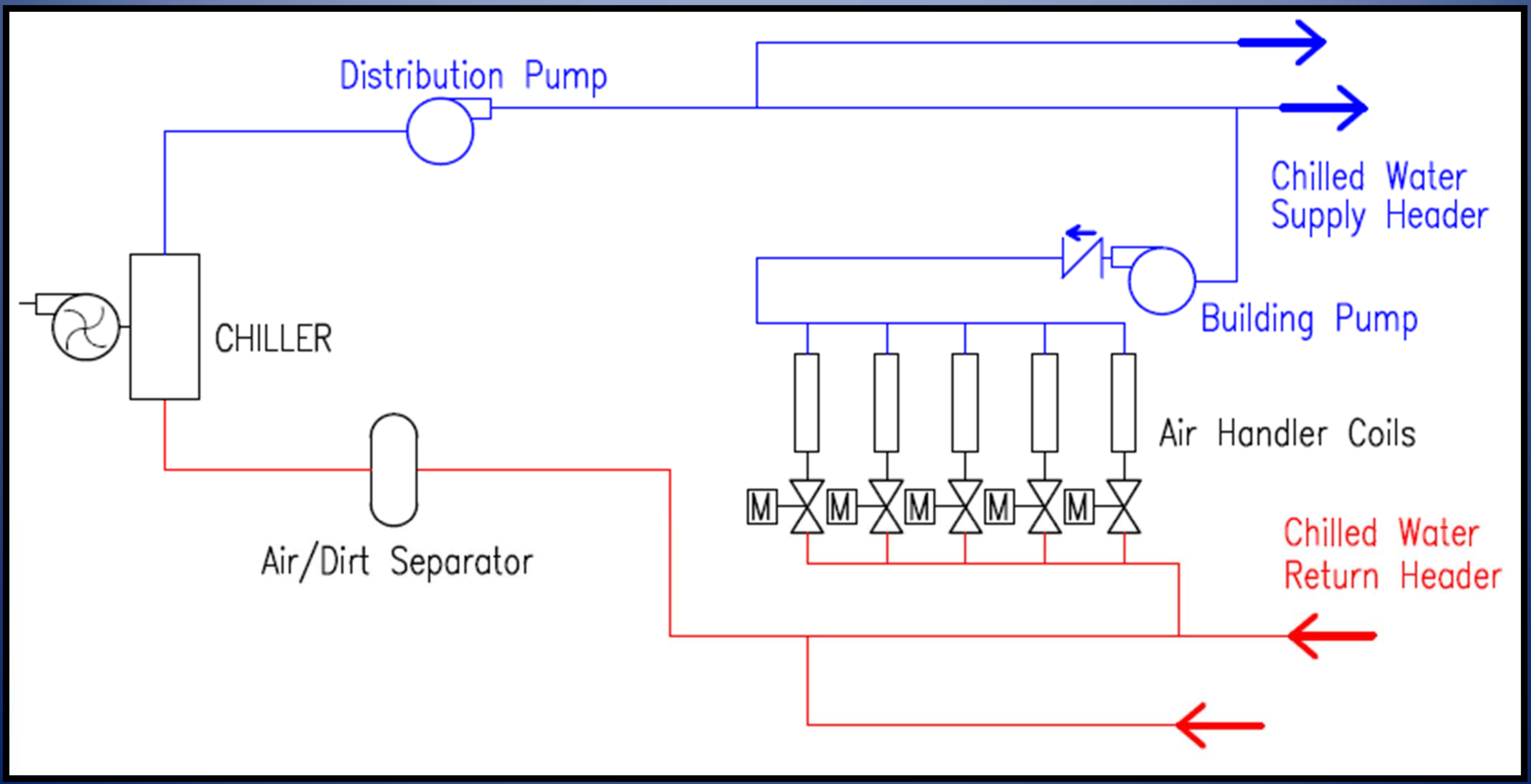
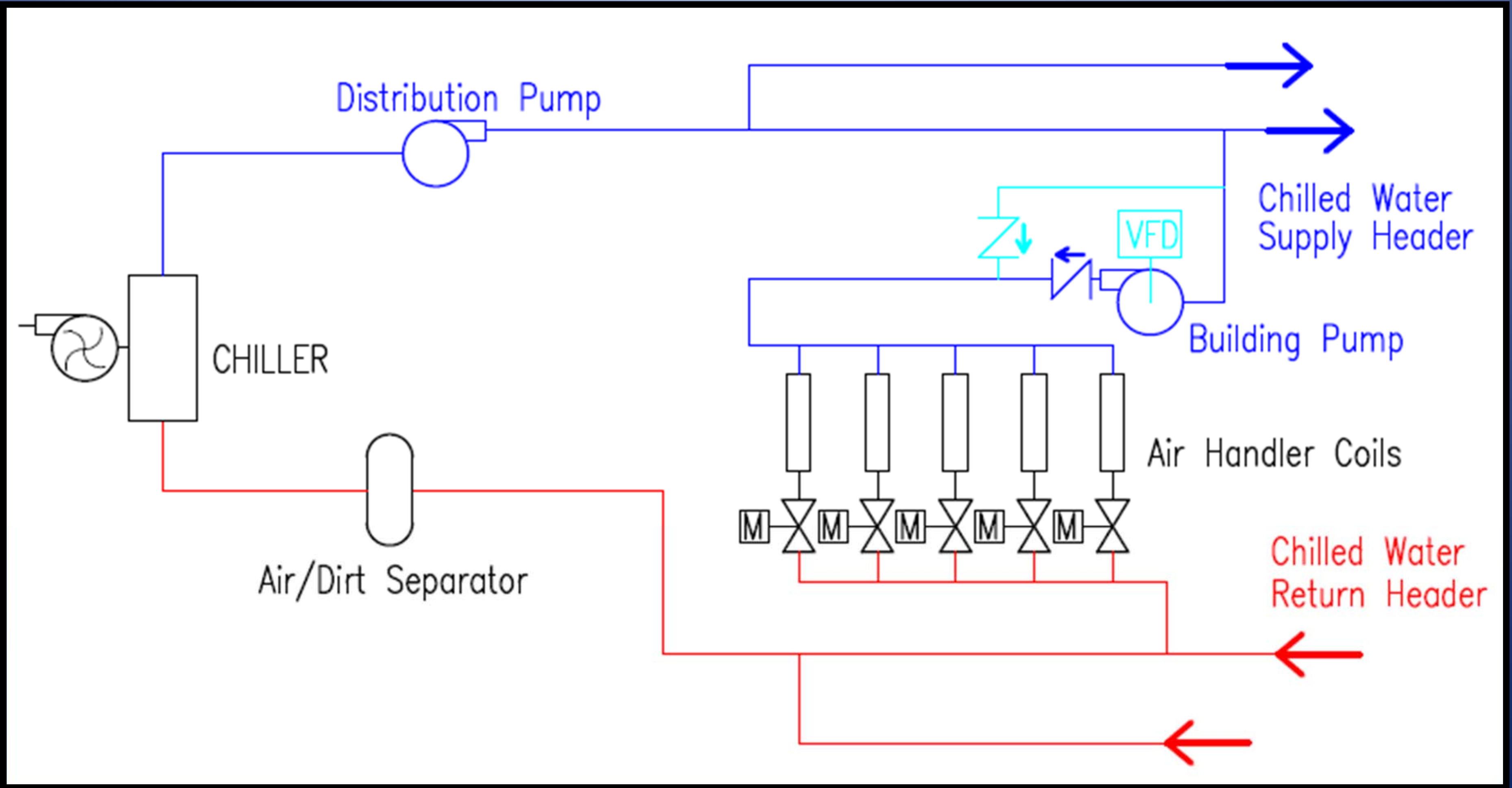


Campus Chilled Water Systems



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Typical Energy Consumption for Various Chilled Water Components KW/TON of Chilled Water Produced							
	Centrifugal Chiller	*Chiller Pump*	*Distribution Pump*	*Tower Pump*	*Tower Fan*	*Building Pump*	*Total*
Range	.4-.7	.03-.20	.05-.30	.03-.20	.05-.15	.02-.25	
Typical	0.51	0.12	0.14	0.13	0.15	0.1	1.15
% of Total	44%	10%	12%	11%	13%	9%	

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- Pumping Fundamentals:
- Pump Energy is proportional to Head x flow
- Required system flow is inversely proportional to delta T.
- Delta T is determined by the design of the end use equipment and the supply water temperature. (And bypass flow)
- A control valve is a pump energy wasting device
- Three way valves should never be installed in a modern chilled water system. NO EXCEPTIONS

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- Chilled system reactions:
- The system return delta T (BY DESIGN) will go up at partial load.
- The system delta T will, by design, will never go below the design coil delta T of the served equipment unless something is WRONG at the heat exchange device!
- Bad delta T causes drastically increased flows which is energy expensive.
- You can solve undersized distribution system problems by fixing AHU coil issues.

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- Solutions to Undersized radial distribution headers:
  - Loop the distribution system
  - Add generation on the far side and back-feed
  - Combine two undersized headers to make one header and simply add one bigger header.
  - Bigger distribution pumps???
  - Fix your low dT syndrome and the headers will no longer be too small!

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- Pressure:
- Controls tech talk about static, steam engineers talk about pressure, chilled water engineers talk differential pressure.
- What is the required chilled water system pressure differential between the supply header and the return header????

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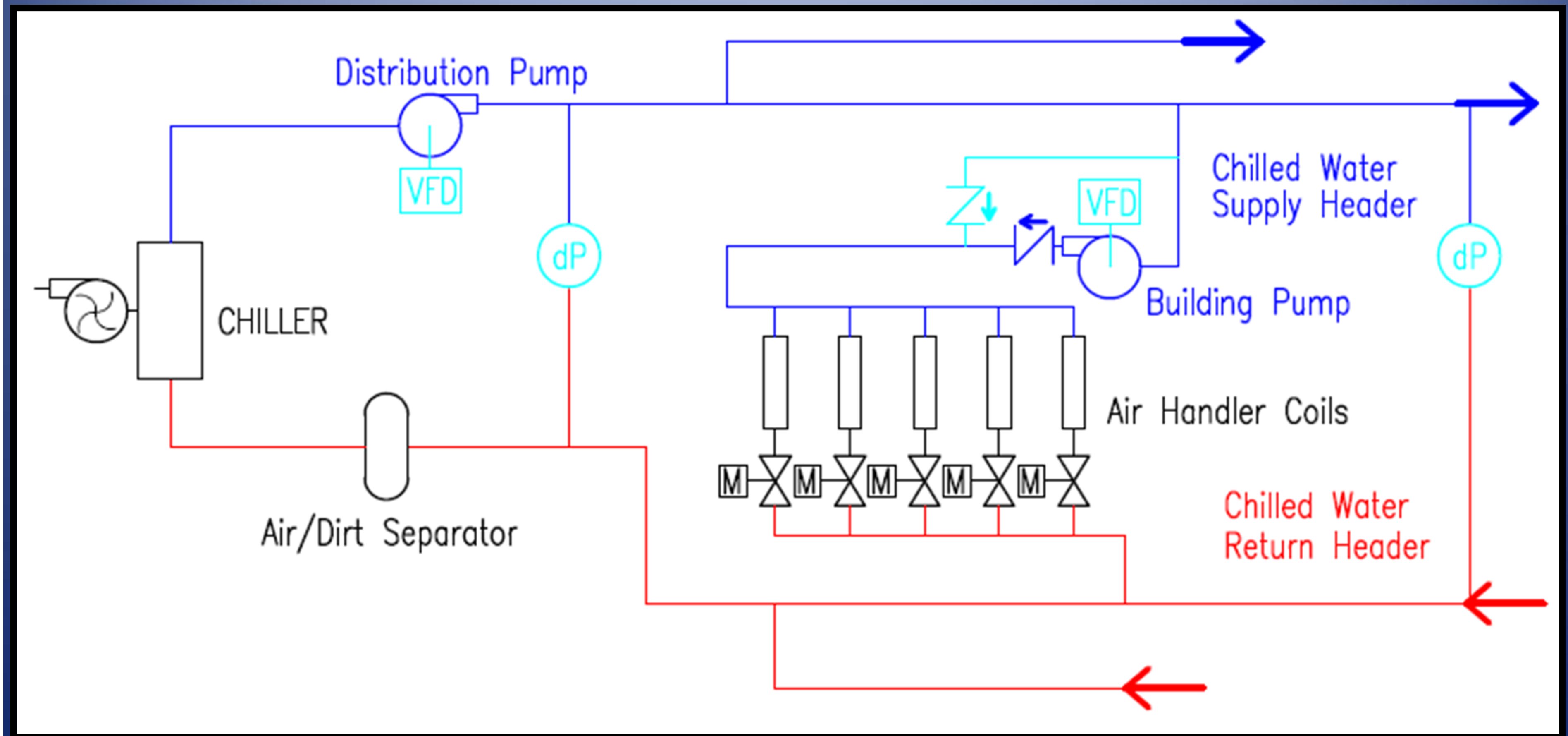

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Opportunity: You just put in the "latest and greatest, State of the Art" Building management and control system that, according to the vendor, can do anything and everything, except deliver coffee to your desk, ….MAKE THE CONTROL SYSTEM TELL ME IF THE CHILLED WATER SYSTEM IS DOING WHAT IT IS SUPPOSE TO BE DOING…..in graphical format please…..

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- What can the chilled water system do?
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  - **Chilled water control valve position!!!**

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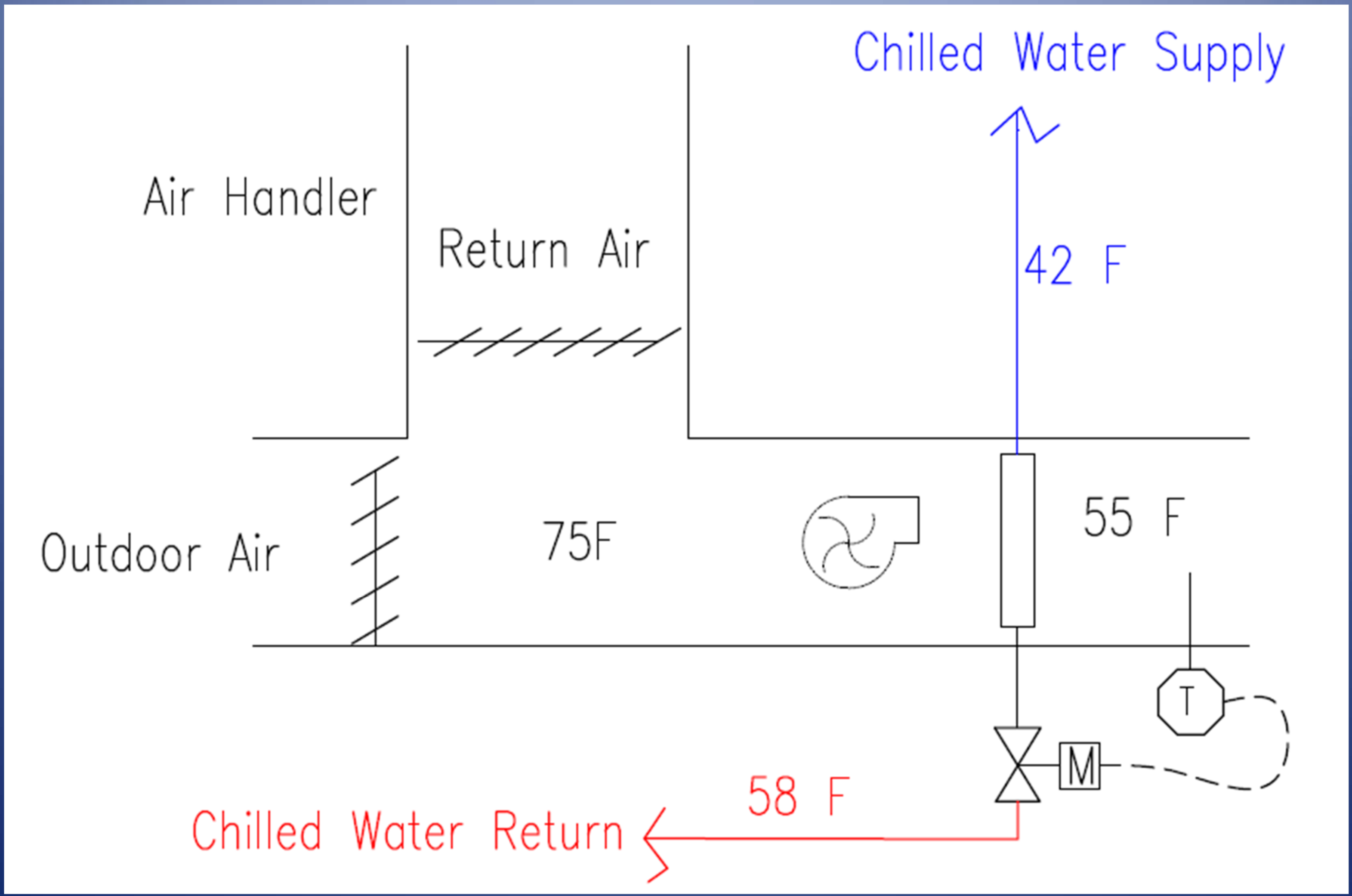

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- How to tell a coil is HAPPY- from a chilled water perspective:
- The chilled water control valve is not full wide open and is thus controlling, the air temp must be correct by control definition!
- Every control valve that is not full wide open is doing its job!
- Every control valve that is throttling is wasting pump energy!

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- Ideal pump energy condition, all system control valves are almost wide open-no wasted pump energy and the air system is satisfied.
- Look at a smaller building system like a reheat system- how is pump speed Controlled?
  – Traditionally- balancer give controls a setpoint
  – My recommendation-Look for the widest open (worst case) control valve in the system and slow the pump down til it is almost wide open and follow.

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- In the chilled water system, look at all the valves in the system and adjust accordingly

WARNING!!!!-DATA OVERLOAD

  - Break down the system by building and look for the widest open valve in the building.
  - Reset dP based on semi-worst case building to keep it in control.
  - Ignore the chronic coils that are always wide open and below design dT!

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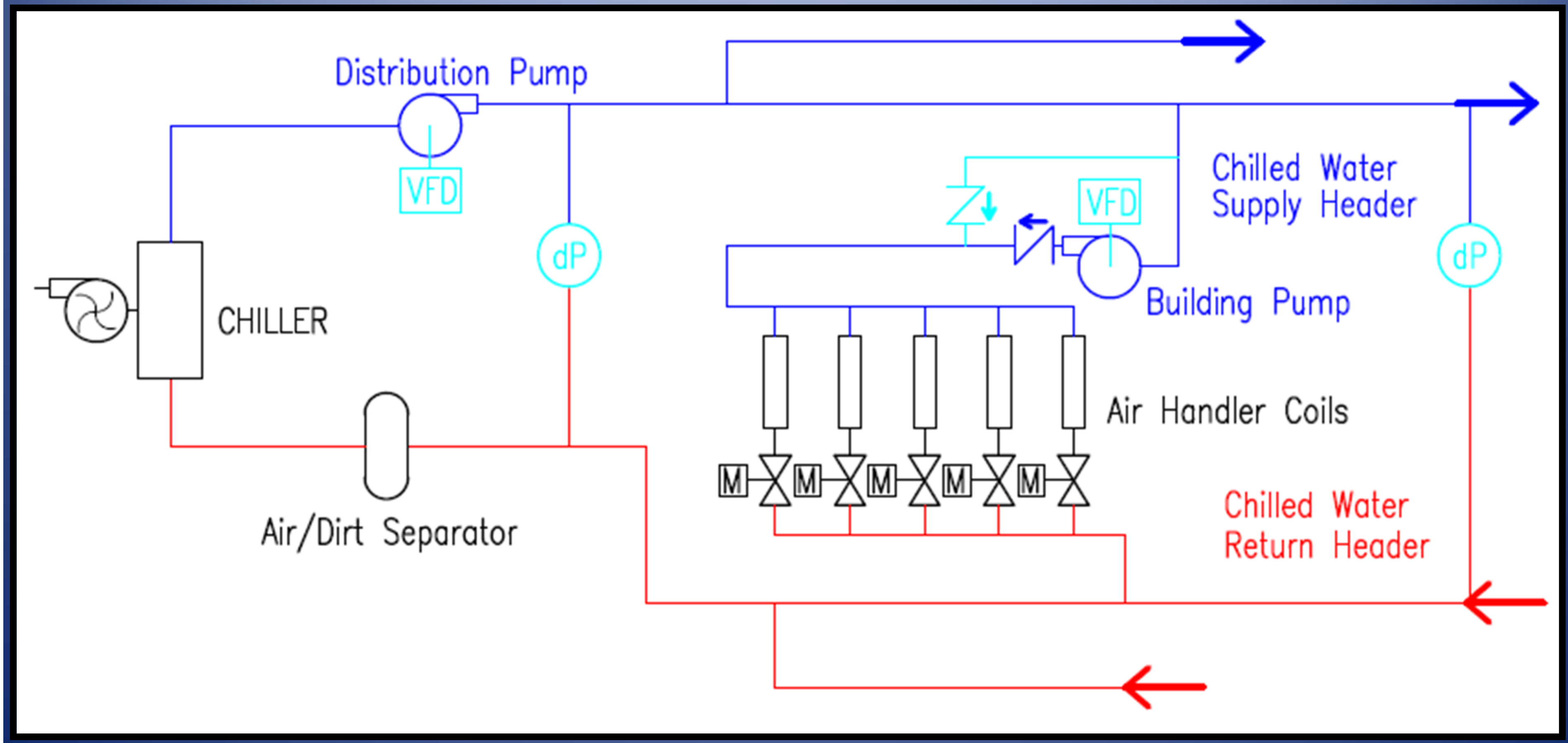

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- Human interface and deductive reasoning capability is imperative!
- Give your operators all the data they need to make informed decisions AND EXPECT THEM TO USE THAT DATA.
  - Input overall power
  - Equipment efficiency
  - Building valve position data

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- Why can you ignore the chronic wide open control valve/bad delta T coils?

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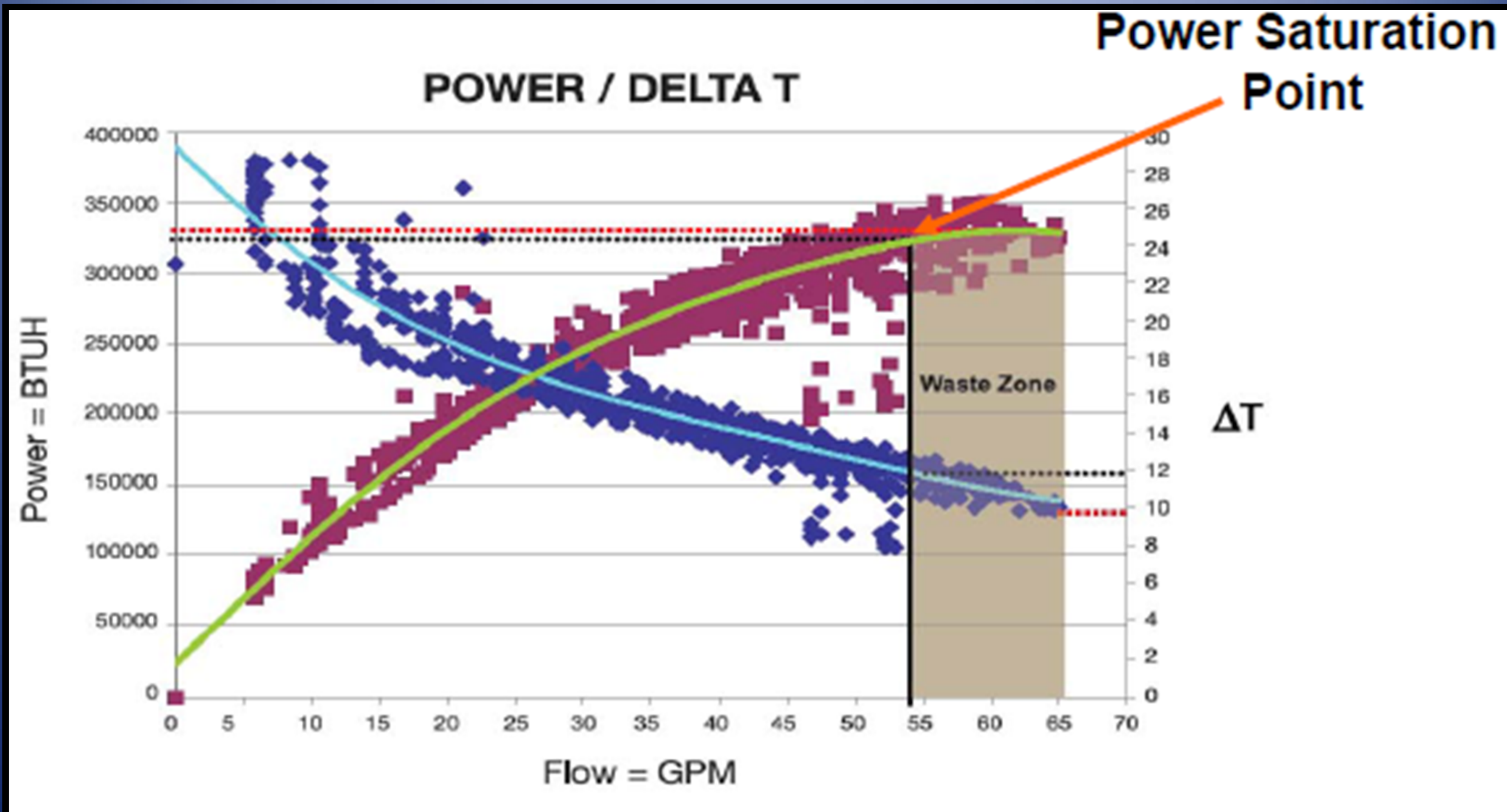

- Graphic courtesy of Belimo Valve Company and MIT case study data via internet.

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- Once the load reaches the Power Saturation point, which will be typically very near the design dT, it doesn't matter how much more water flow you supply, the supply air temp will not change, but the chilled water delta T will continue to decrease and the valve will stay wide open. This is the major cause of low Delta T syndrome.

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- What causes a heat exchanger (COIL) to reach power saturation?
  - Too Much Air flow
  - Too high of inlet temperature/humidity
  - Too low of discharge air setpoint
  - Insulating material (DIRT) on outside of coil
  - Insulating material (DIRT OR AIR BUBBLES) on inside of coil tubes
  - Wrong Size Coil
  - Wrong Size Replacement Coil!!!

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- What causes a heat exchanger (COIL) to reach power saturation? (Continued)
  - Biofilm
  - Coil Spec'd with low design delta T
  - Low bid "fudged" the performance capability of his coil
  - Temp Transmitter for Controller out of Calibration!
  - Supply chilled water temperature too high!
  - Control Valve Hunting

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- Why do “tuned” chilled water control valves Hunt?
  - System differential pressure needs to be maintained very, very, very constant! (+/- a few inches differential-not a couple of psid)
  - The lower the system dP, the wider open the valve, the better the control valve authority. (no banging off the seats)
  - dP is directly proportional to pump energy.

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- Bottom Line-Does these things save energy?
- At UNMC, in two years we went from a delta T of 7F to nearly 14F.
- This year we reduced our peak demand 2 MW (out of 28MW) and we expect the same reduction again next year. Reduced energy consumption by nearly 20%, we expect similar reductions again next year.

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- HOW?
  - Changed most of chilled water system to Variable Primary flow from decoupled system.
  - Two new higher efficiency chillers
  - New campus building automation system
  - Replaced bad coils and control valves
  - VFD on all air handler fans
  - Improved operational philosophy and operator control engagement.
  - Started continuous commissioning and optimization

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- Heat Recovery Chillers
- In the central utility plant we take heat from the chilled water system and pump it's temperature up high enough to get it to flow to the atmosphere to get rid of it, then turn around and burn fuel to make steam to send heat back to the building. Instead of dumping the heat to atmosphere, why don't we recapture it and reuse it???

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- Chillers can readily make 140F condenser water while making 40 degree chilled water (100F lift)
- Most reheat systems, even when designed for 180F water, will work with 140F supply water.
- With a central chilled water system, there is typically a year round heat source (heat pump loops, air side economizers) that is dumped to the atmosphere that could be used for reheat chillers.
- The Economics routinely work on a scale and volume to make it worth your while!

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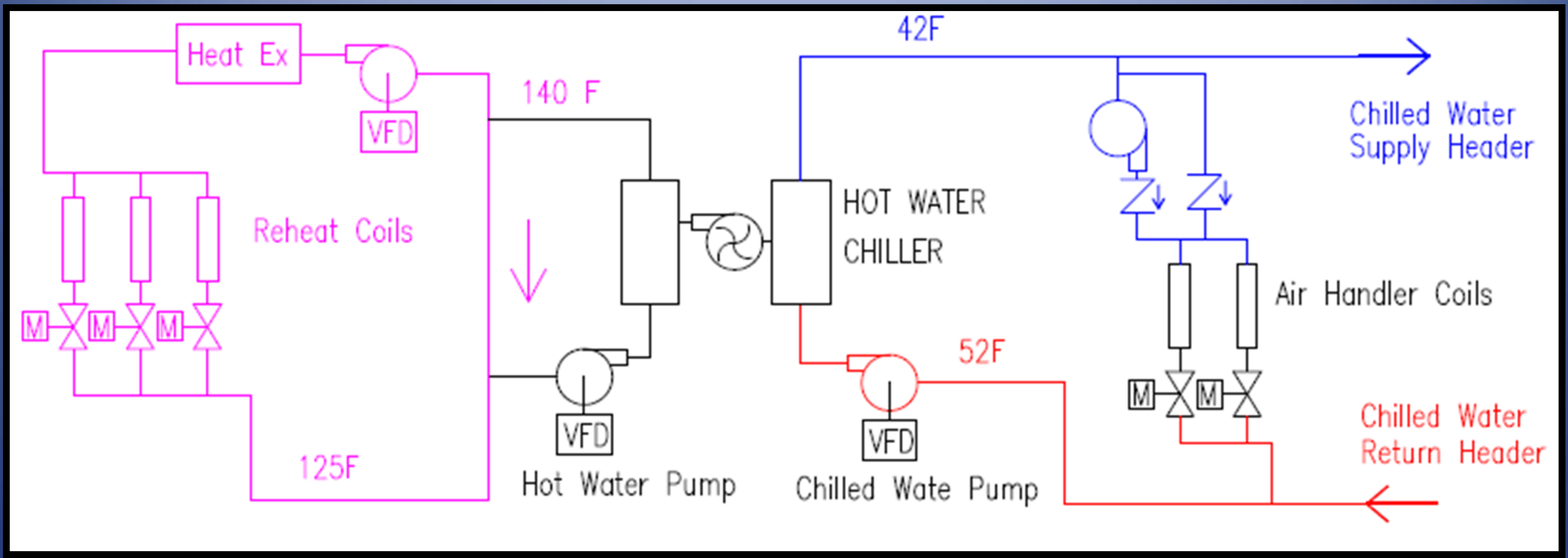

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- Chilled water is considered your waste Product- Don’t mess up you system efficiency.
- Typically 2.2 KW/Ton chilled water produced.
- Typically 1.3 tons of hot water produced per ton of chilled water.
- Typically installed at the building level, but chilled side is located on the campus grid.
- Hot water side is typically decoupled
- Don’t run during electrical peak conditions unless you generate you own electricity.

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Thank you!

Any questions?

To contact me

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