CHILLERS AND VARIABLE PRIMARY FLOW
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HTS Lunch and Learns

• Once a month
• Covering all topics in HVAC
• February - Fan, Applications, and AHUs
• March – Humidification
• April – Heat Recovery Systems
• May – Optimum Air
• June – Pumps/HX/Hydrronics
• Sept – Refrigeration Cycle
• Oct - Chillers
Chillers

Chiller Basics

• Make cold water by removing heat
• Reject heat to water loop, or ambient air
• Scroll, Screw and Centrifugal compressors
• Constant/Variable Speed
• Ball, Oil, or Magnetic Bearing
• Efficiency rated on IPLV
• Refrigeration Presentation September
• Chiller Presentation October
**Air Cooled**

**Advantages**
- Packaged product
- No cooling tower or condenser loop
- Can have integral pumps and airside economizer
- Do not take up indoor floor space
- As small as 3 Tons

**Disadvantages**
- Inefficient compared to water cooled (IPLV 0.85 kW/Ton)
- Must be outside, can cause noise/architectural concerns
- Not custom designed
- Limited to about 500 tons, biggest that fits on a truck
- Glycol may be required
Water Cooled

Advantages
• Very efficient (IPLVs < .35 kW/Ton) (chiller only)
• Located inside a building
• Wider size range (30-8000Tons)
• Centrifugals are semi-custom designed for each application

Disadvantages
• Require separate condenser water loop and cooling towers
• Require additional set of pumps
• Take up floor space indoors
Compressors – Scroll

- Physically compress the refrigerant
- Contains two scrolls meshed together
- One rotates off-center to the other fixed one
- Used in a wide variety of applications, largest operating envelope
- Copeland Digital Scrolls – disengage scrolls
- Daikin Inverter Scrolls – VFD scrolls
Compressors – Screw

- Physically compress the refrigerant
- Contains 1 or 2 interwinding screws
- The space between the screws becomes smaller as the refrigerant moves through
- Can be unloaded better than a scroll compressor
- Use slide valves to uncover the screw
Compressors – Centrifugal

• Similar to a pump
• Uses velocity pressure to compressor the refrigerant
• Most efficient, tightest operating envelope
• McQuay uses a Hydrodynamic Bearing, shafts rotates on a film of oil
• McQuay uses a high speed (20000 RPM), smaller impellers, smaller compressors, gear ratio
• Use variable inlet vanes, diffuser plates to unload
Compressors – Unloading Centrifugal

- McQuay uses diffuser plates and variable inlet vanes
Compressors - Magnetic Bearing

• Shaft rests on magnets
• 60-1200 Tons
• McQuay is planning on matching the 1200 tons
• Power loss – rundown can power the magnets
• Come standard with VFDs
• IPLV of <.40kW/ton is common, <.35 kW/ton possible
• Very quiet, pump next to it was louder
Dual Compressor

Single Circuit Dual Compressor
• 60% capacity with one compressor running
• Offers excellent part load performance

Dual Circuit Dual Compressor
• Fully independent systems
• Offers full redundancy in a single machine
• Counter flow design offers improved full load efficiency
Drive

Open Drive - York

- Motor is open to the outside
- Contaminants can reach the motor
- Refrigerant seals may fail and cause leaks
- Adds heat to mechanical room

Hermetic – Trane, Carrier, McQuay

- Compressor is completely sealed as part of the refrigeration circuit
- Motor is cooled by refrigerant, no excess heat
- No seals on moving parts
Positive vs. Negative Pressure

Positive Pressure – York, McQuay, Carrier
• Refrigerant circuit is always a higher pressure than the ambient
• Leaks out rather than in, easy to find a leak

Negative Pressure - Trane
• At some points the refrigerant is a lower than atmospheric pressure
• If a leak develops can suck in contaminants to refrigerant cycle
• Used with R-123, production of new machines banned after 2020, production of refrigerant banned after 2030, 19 years away
Aermec

New line by HTS

• Made in Verona Italy
• Worlds Quietest Fan Coil with NC-25
• Line of chillers and air to water heat pumps from 3-250 tons
• Integral pump and buffer tanks
• Full waterside economizer (free cooling below 30F for 44F water)
Hydronic Systems

- Move thermal energy around a building with water
- Interact with heat exchangers (coils, chillers, etc.)
- Chillers designed for 2.4 GPM/Ton chilled water loop
- Chiller efficiency improved by large temperature delta and high LWT
- Old systems used constant flow, flow through chiller could not vary
- Pumps operated at 100% all the time, only needed 1% of the time
Variable Primary Flow

• First attempted 1996
• Allow flow through chillers to vary
• Temperature delta maintained during operation
• Required new technology and control advances
• Offers lowest energy consumption
• Simple
Motivation

Why Does VPF interest Owners?

• They can save money!
Constant Flow – The original

**Advantages**
- Simple Design
- Easy Control
- No VFDs

**Pitfalls**
- Flow is constant at all loads
- Poor low load operation

**Why Not Variable Speed**
- Chiller required constant flow
- Chiller could not handle both changing flow and temperatures
Constant Flow – Dual Chillers Split Pumps

Advantages

• Good for part Load
• Can stage chillers
• Easier to turn on/off chillers

Pitfalls

• N+1 redundancy for each chiller
• Flow is at minimum the design of smallest chiller
• Chiller mixing raises LWT
• Isolation Valves
Constant Flow – Dual Chillers Headered Pumps

Advantages
• Better staging of pumps
• Chillers/Pumps independent
• N+1 redundancy is cheaper

Pitfalls
• Chillers see same part load
• More expensive and complex than split pumps
• LWT can rise due to mixing
Constant Flow – Multiple Chillers Multiple Headered Pumps

Advantages
• Better turndown

Pitfalls
• Problems exaggerated
• Worse Mixing
Variable Flow – Primary-Secondary Loops

Advantages
• Variable flow in the building
• Chillers still experience constant flow
• Can run loops at different temperature ranges

Pitfalls
• Primary loop still constant flow
• Two sets of pumps
Low Delta-T Syndrome

- Problem on Load side
- Caused by valves opening
- Flow becomes too high for load
- Additional chillers/pump turn on
- Can happen with any design

- Keep coils clean
- Do not lower AHU setpoint below design
Looking Back - Pitfalls

- Poor modulation
- Constant flow at all loads
- Two sets of pumps
- Complicated design
- Poor control on water side
- No preferential loading
- Water mixing raises LWT
Variable Primary Flow

Advantages

• Variable flow through the entire loop
• Removes secondary pumps
• Allows preferential loading and staging of chillers/pumps
• Simple design

Disadvantages

• Still requires a minimum flow in bypass line
• Require flow monitoring and isolation valves
Variable Primary Flow – Chillers

- Let us know if you want VPF
- Chiller selected for high turndown
- High design pressure drop vs. low minimum flow
- Identical chillers
- Selected for plateau loading
- One good part load, other good full load machines
- Staging on/off
Variable Primary Flow – Piping

- Isolation valves in front of each chiller
- Valves must be slow opening type
- Bypass line sized for 30-50% of largest chiller
- Bypass line can be near chillers with two way valve or using three way valves around load
- Pumps can be before/after chillers
- Design pump head can be higher than Primary-Secondary
Variable Primary Flow - Controls

- BAS required
- VFD modulates to pressure across load
- Chiller must have sufficient onboard controls
- Each chiller requires flow meter or pressure differential
- Important to slowly open isolation valves
- Max flow change of 10%/min
- Bypass valve is normally closed
Variable Primary Flow - Summary

- Advanced Chiller Controls
- Bypass Line
- Single Set of Pumps
- Reduced Energy Consumption
- Flow change 10%/min
- Simple Design

Questions?
Next Time – February 16th

Fan, Applications, and AHUs

• Fan Types
• Fan Laws, Curves
• Direct vs. Belt Drive
• Inline, Centrifugal, Roof, Indoor
• Haakon Vs. McQuay
• Indoor Vs. Outdoor