Seminar 69 -- Fundamentals of Centrifugal Chillers

Operation and Efficiencies of the Compressor, Evaporator and Condenser

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Outline/Agenda

- Chiller Process via PH Diagram
- Chiller Applications Based on Load and Lift
- Evaporator and Condenser Performance
- Centrifugal Compressor Operation
- Surge, Choke, and Stall
- Extending the Centrifugal Chiller's Operation Map
- Chiller Selection Understanding

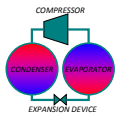
Learning Objectives

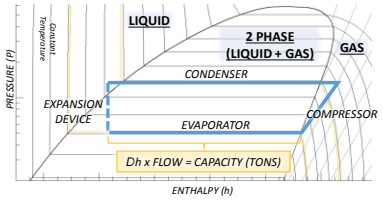
1. Convey the basic operation of a Centrifugal Chiller.
2. Explain the differences between a Centrifugal Chiller and a positive displacement chiller.
3. Describe the typical options that are available when specifying centrifugal chillers, what the option provides and what the advantage of the option is.
4. Define centrifugal chiller efficiencies and explain the requirements of ASHRAE 90.1 relative to centrifugal chillers.

Brief Centrifugal Chiller Review

To understand how centrifugal chillers are sized and selected, we need to understand how the process works relative to pressure and capacity.

- Chiller Process Component Overview
- Head Pressure/Chiller Lift
- Capacity/Flow





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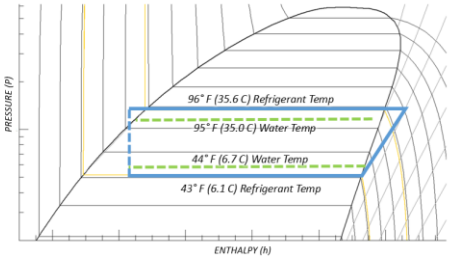
Heat Exchanger (Condenser and Evaporator) Performance

The best performing heat exchangers will have the smallest approach.
Limited by Cost of Heat Exchangers.



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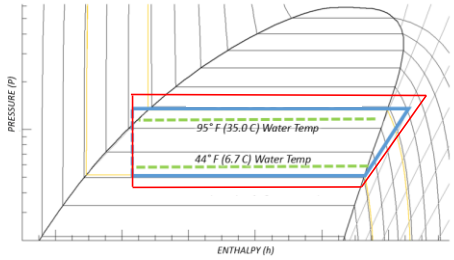
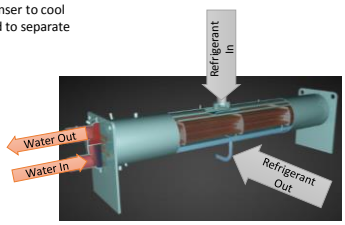


Condenser: How it Works.

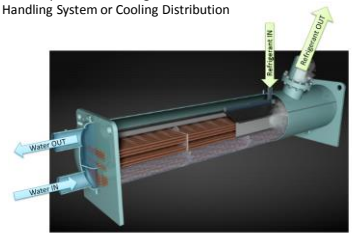
- Condenser receives cool water from a separate system to be used in the Refrigeration Cycle.
- Water is then heated in condenser to cool refrigerant and heat is rejected to separate system.



Evaporator: How it Works.

The Evaporator takes the heat from the building/system in need of cooling and returns chilled water to the building for cooling.

- Done through Heat Transfer, Evaporation of Refrigerant.
- Works with Building Air Handling System or Cooling Distribution Equipment.

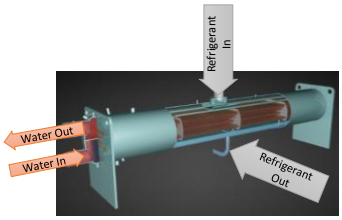


Condenser Performance

Condenser performance affected by following design options.

Condenser Approach Determined by:
- Number of Tubes
- Tube Size/Type
- Heat Transfer Surface

Condenser Approach Affected by Operation:
- Refrigerant Leaks
- Fouling
- Flow Blockage by Open loop Substance

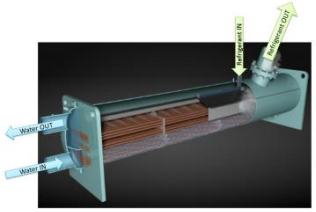


Evaporator Performance

Evaporator performance affected by following design options.

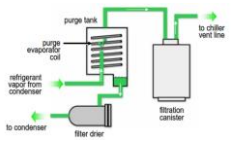
Initial Evaporator Approach Based on:
- Number of Tubes
- Tube Type
- Refrigerant Dispersion
- Heat Transfer Surface

Without Maintenance,
Approach Increases During Operation
- Dirty Tubes
- Flow Blocked by Open Loop Substance
- Refrigerant leaks



Leaks Affect System Performance

Low Pressure Systems:
- A purge system is required for low pressure refrigerants to remove non-condensables from the system.
- Operating Pressure < Atmospheric, air leaks into chiller

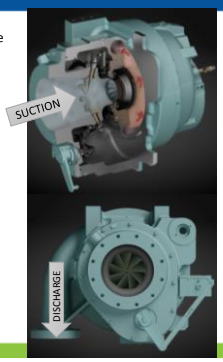


Medium or high Pressure Systems
- Require refrigerant detection device
- Operating Pressure > Atmospheric, refrigerant leaks out

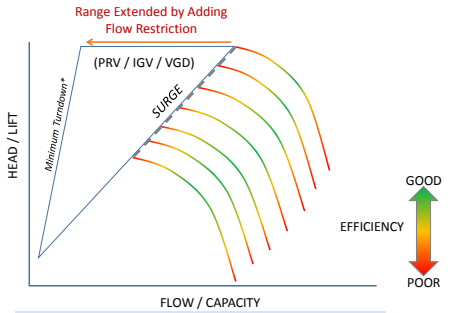
Centrifugal Compressor

The centrifugal compressor performs the work of the chiller.

- Drives refrigerant flow (capacity) through chiller.
- Takes suction gas from evaporator and compresses refrigerant to increase refrigerant pressure.
- Gas discharges through to the condenser.



Extending the Capacity Capability by Restricting Flow

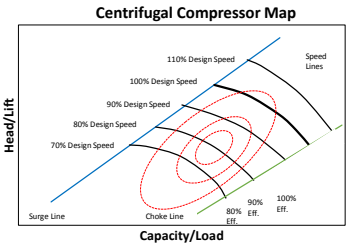


*% Turndown capability may vary with head/lift

Centrifugal Compressor Operation

Centrifugal Chiller Operation is limited to the Centrifugal Compressor Operation Map.

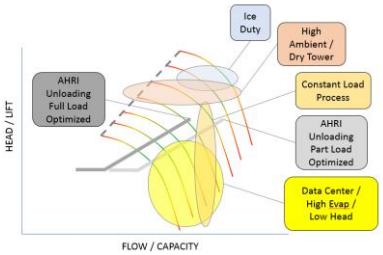
- Fixed Speed Compressor operates at one speed line seen to the right.
- Variable Speed Drives allow for Operation at a Variety of Speed Lines without gear changes required.
- Without restricted or interrupted flow, centrifugal chiller must operate between surge and choke line.



Centrifugal Compressor Applications

All Applications can be defined by a capacity vs. head pressure operation map.

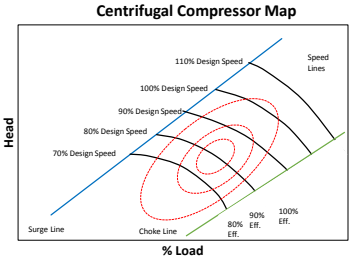
- Common Applications
- Operating Map: Load vs Lift



Centrifugal Chiller Limitations

The centrifugal chiller has operational limitations based on system component selection.

- Surge: Backflow of refrigerant from the condenser.
- Condenser Pressure too great for compressor to overcome.
- Surge is a system instability
- Stall: Immediately before surge, sound comes from reduced flow.
- System in stall is still stable, just likely loud.
- System Choke, High Flow Limitation



Rating a Centrifugal Chiller

There are many ways to rate a chiller. Standard Options are included in table below.

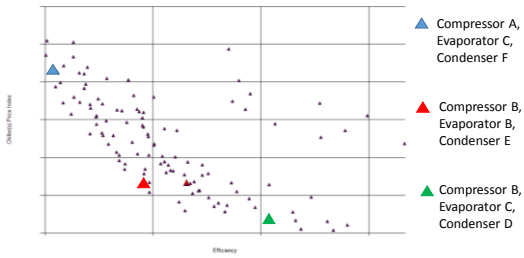
Standard Chiller Selection	
Capacity	400
Evaporator Entering Temperature	54
Evaporator Leaving Temperature	44
Evaporator Flow	
Condenser Entering Temperature	85
Condenser Leaving temperature	95
Condenser Flow	
Refrigerant Type	
Line Frequency/Voltage	460/60
Starter	VSD w/Filter
Evaporator and Condenser Fluid	Water
Pressure Drop	30
Number of Passes	2
Tube Velocity	12

As seen, each Selection has hundreds of Combinations.

Can limit based on:

- ASHRAE 90.1 or Other Required Accreditation
- Water Pressure Drop Limitations
- Customer Flow and Water Temperature Requirements
- Chiller Unloading Requirements:

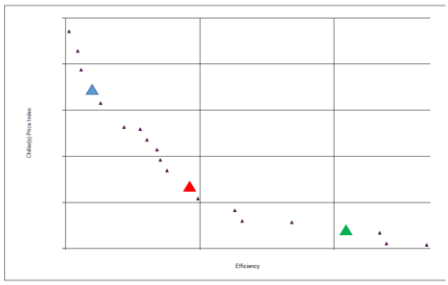
Chiller Selections Based on Single Design Point



Conclusion

- Chiller Component basics
- Heat Exchangers Goal is to have smallest approach possible
- Compressor Drives the System
- Many Different Combinations Available
- Selection Must be Based on Customer Requirements
- Many Different Applications based on Load and Lift Variables

Chiller Selections Optimized



Questions?

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Chiller Selections

High Efficiency, High Cost	Life Cycle Customer
Medium Efficiency, Medium Cost	Value Customer
Lower Efficiency, Lower Cost	Budget Customer