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REDUCING COMMERCIAL REFRIGERATION SYSTEM ENERGY USE

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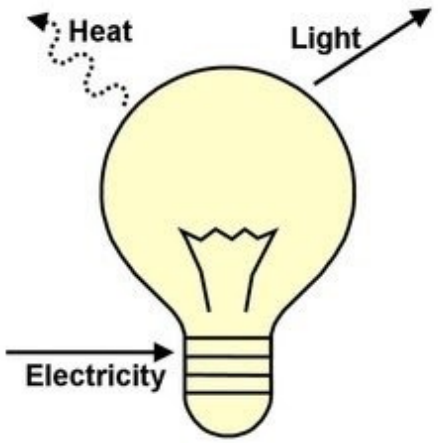
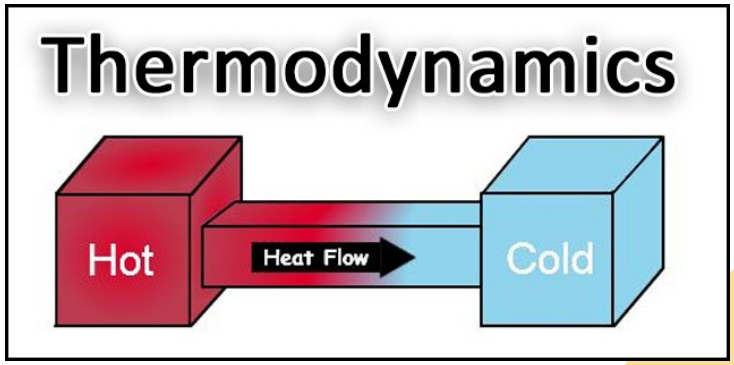
Center for Energy and Environment

Basics of Energy and Heat

- Energy can't be destroyed or created only transformed
- Heat is a form of energy
  - Measured in BTU's
  - BTU/hr is a rate of heat
  - 12,000 BTU/hr = 1 Ton of cooling
- It moves naturally from hot to cold
- Refrigeration is trying to do the opposite



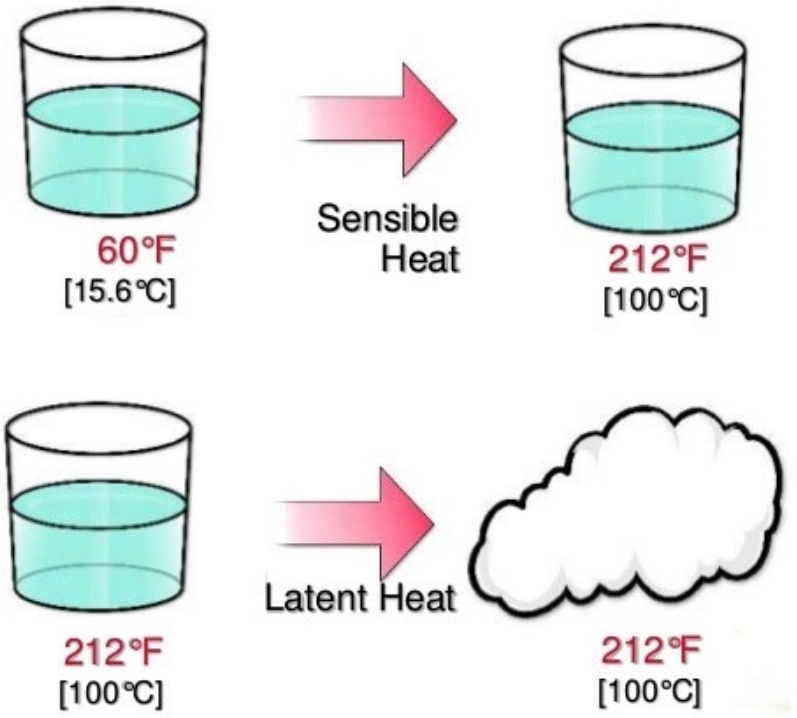


Key Themes of Presentation

- Refrigeration Fundamentals
  - Refrigeration cycle and how it works
  - Components
- Refrigeration Systems
  - Grocery store—especially larger w/central rack(s)
  - Ice arena
- Reducing Refrigeration System Energy Use
  - Reducing load
  - Raising suction pressure
  - Lowering head pressure
  - Making components more efficient
- OTP Rebate Eligible Equipment

Basics of Energy and Heat

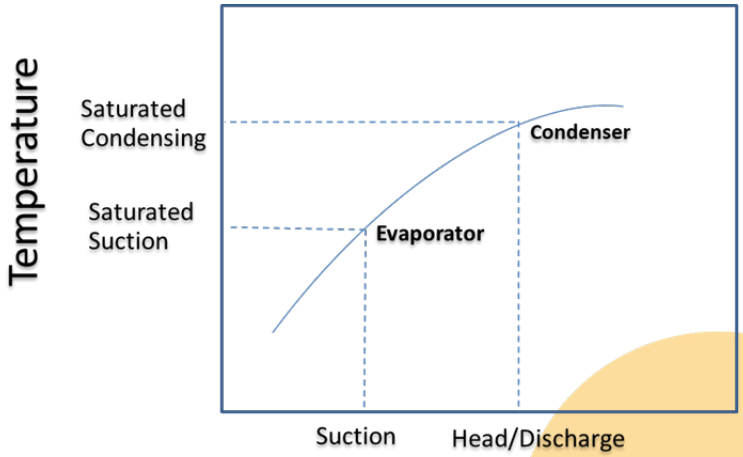
- Sensible Heat – Heat that changes the temperature of an object
- Latent Heat – Heat that changes the state of an object
  - Ex: Liquid to vapor
  - Doesn't affect temperature
  - Much more energy is stored/released in latent heat



Basics of Pressure

- Refrigerants begin to evaporate at a higher temperature as its pressure increases
- Refrigerants begin to condense at a lower temperature as its pressure decreases
- Each condensing or evaporation pressure has a corresponding temperature

PRESSURE/TEMPERATURE CHART FOR R-22					
PRESSURE	**TEMP**	*PRESSURE*	*TEMP*	**PRESSURE**	**TEMP**
63 psig	**36°F**	*101 psig*	*60°F*	**210 psig**	**105°F**
66 psig	**38°F**	*111 psig*	*65°F*	**226 psig**	**110°F**
69 psig	**40°F**	*121 psig*	*70°F*	**241 psig**	**115°F**
72 psig	**42°F**	*133 psig*	*75°F*	**260 psig**	**120°F**
74 psig	**44°F**	*144 psig*	*80°F*	**279 psig**	**125°F**
78 psig	**46°F**	*155 psig*	*85°F*	**298 psig**	**130°F**
81 psig	**48°F**	*168 psig*	*90°F*	**316 psig**	**135°F**
84 psig	**50°F**	*183 psig*	*95°F*	**340 psig**	**140°F**
93 psig	**55°F**	*195 psig*	*100°F*	**361 psig**	**145°F**



Basics of Pressure

- Condenser (Head/Compressor Discharge) Pressure
  - Condenser Saturation Temperature (CST)

- Evaporator (Suction) Pressure
  - Saturated Suction Temperature (SST)

PRESSURE/TEMPERATURE CHART FOR R-22					
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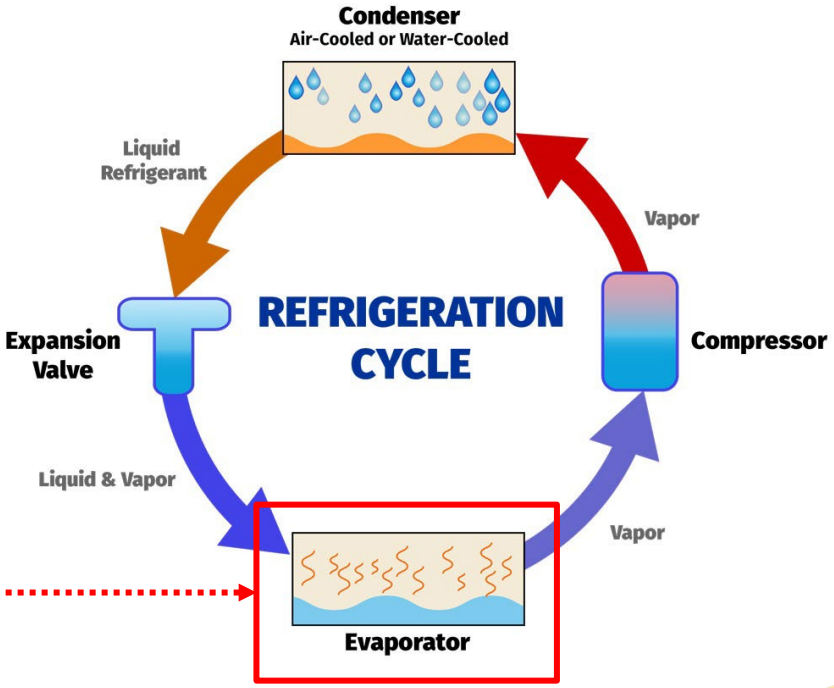
Refrigeration Cycle

- 4 Main Components
  - Evaporator
    - Heat is absorbed into the refrigerant
    - Refrigerant evaporates into a vapor
    - Must be colder than the warm space/object



Evaporator - Purpose

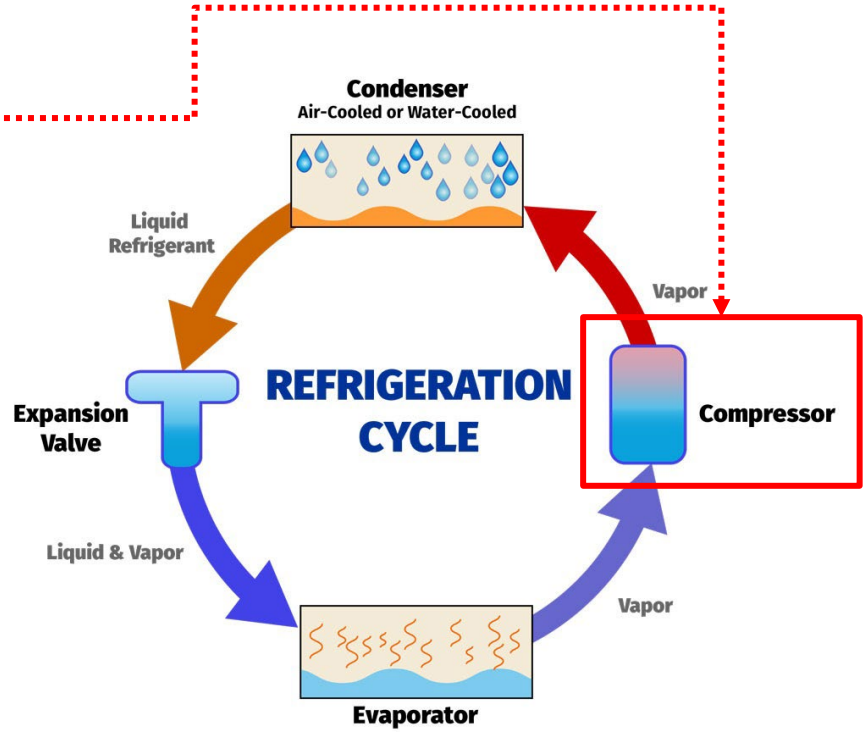
- Removes unwanted heat from space
- Low pressure, temperature mixture of liquid/vapor enters
- Low pressure, temperature vapor leaves
- Fans move room air over coils
  - Heat absorbed by refrigerant

Grocery Store Refrigeration Systems

- Goal is to maintain space temperatures for coolers, freezers and cases
- Two product temperatures
  - Medium temp. – Coolers, produce/dairy/lunchmeat cases
  - Low temp. – Freezers, frozen food cases

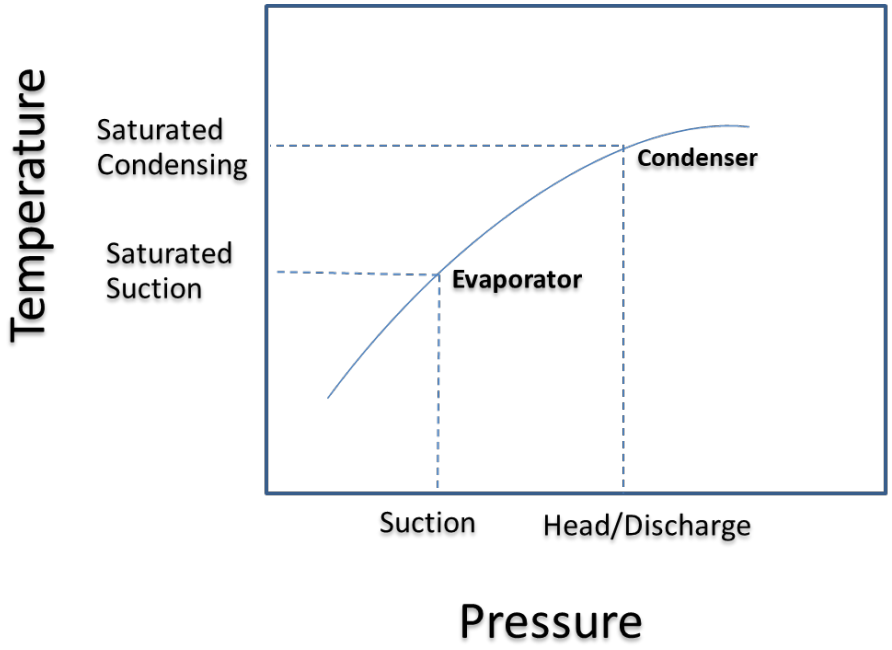
Refrigeration Cycle

- 4 Main Components
  - Compressor
    - Sucks in low pressure vapor and increases its pressure
    - Most energy intensive component
    - Efficiency decreases as the pressure/saturated temperature different between evaporator and condenser goes up



Compressor - Purpose

- Increases pressure of refrigerant vapor
- Low pressure and temperature vapor enters
- High pressure and temperature vapor leaves
- The larger the difference in entering/leaving pressures the more “uphill” energy required
- ***NO liquid refrigerant***

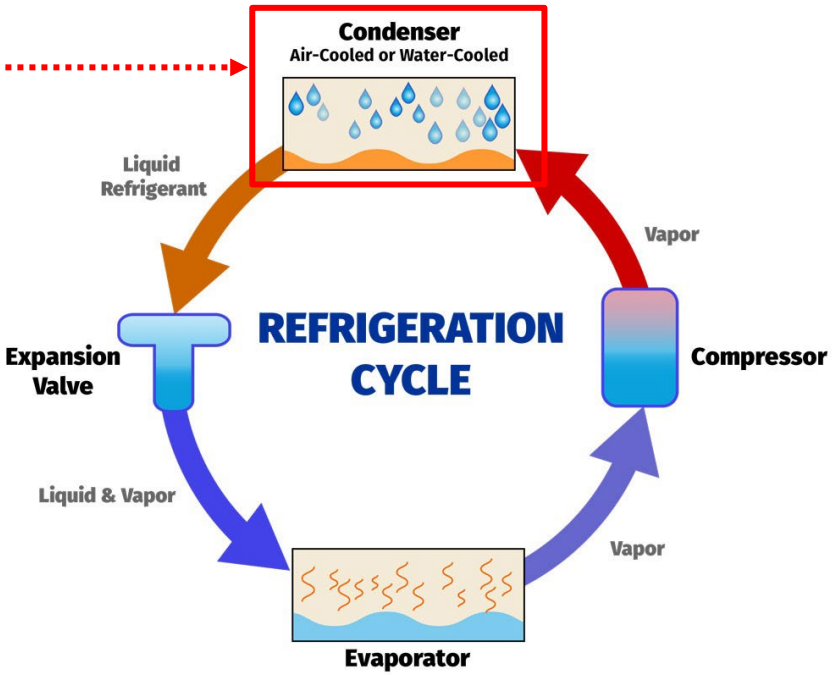


Grocery Store Refrigeration Systems

- Central rack systems
  - Usually, semi-hermetic compressors
  - Split into low and medium temp suction groups
  - Controlled to maintain saturated suction temperature
  - Lowest saturated suction temp dictates compressor setpoint

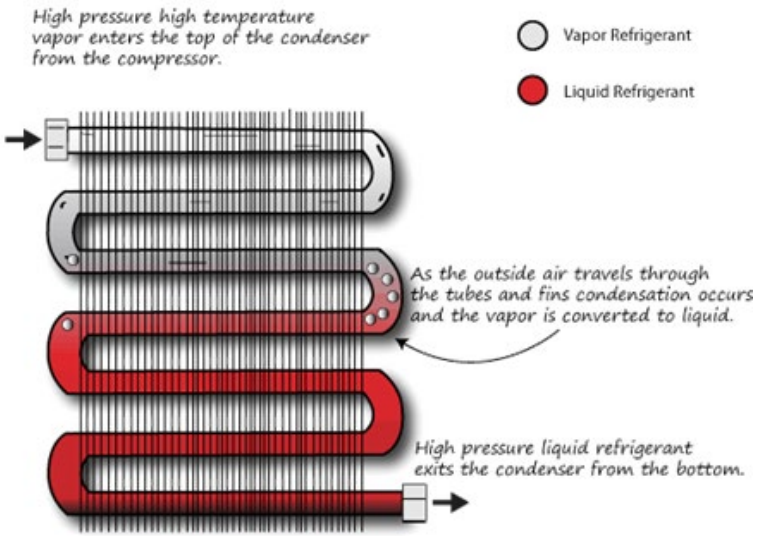
Refrigeration Cycle

- 4 Main Components
  - Condenser
    - Heat from evaporator and compressor is rejected
    - Refrigerant condenses and leaves as high pressure, liquid
    - Energy is used to reject heat



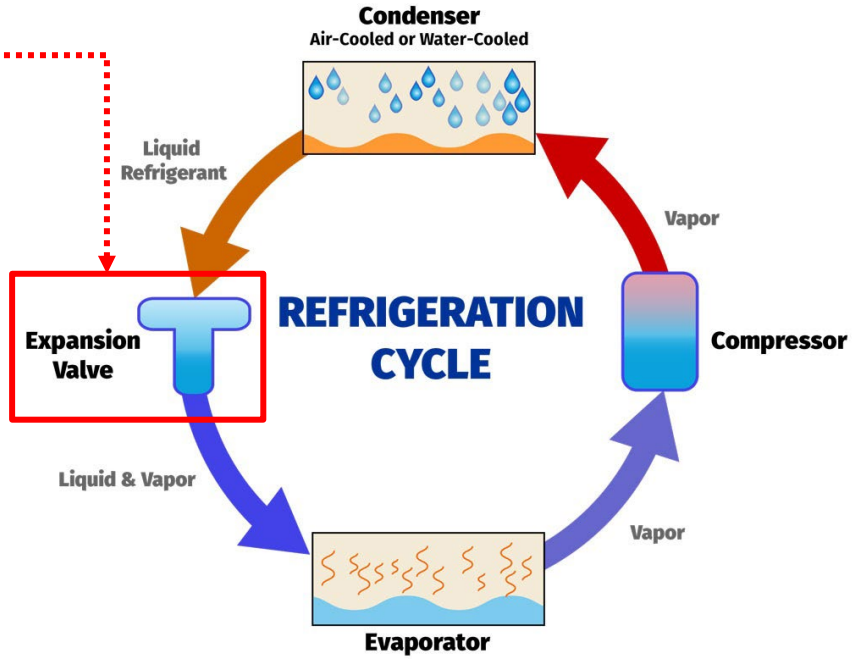
Condenser - Purpose

- Rejects heat from;
  - Compressor
  - Heat removed from evaporator
- High pressure, temperature vapor enters
- High pressure and medium temperature liquid leaves
- Refrigerant temperature must be higher than cooling medium
- Fans assist with removing heat



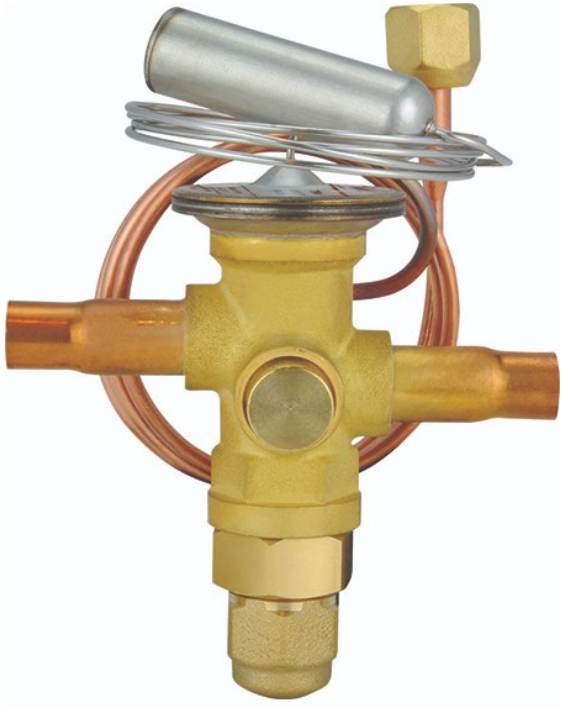
Refrigeration Cycle

- 4 Main Components
  - Expansion Valve
    - Decreases pressure and temperature of refrigerant
    - Mixture of liquid/vapor leaves
  - Cycle repeats



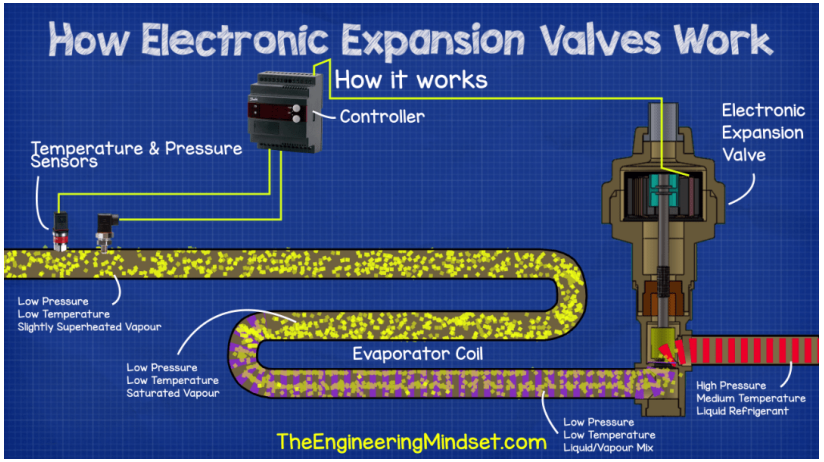
Expansion Valve - Purpose

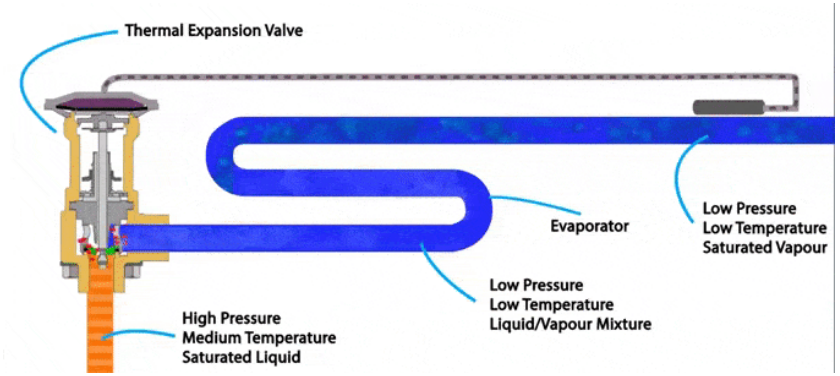
- Meters amount of refrigerant entering evaporator
- High pressure, medium temperature liquid enters
- Low pressure and temperature liquid/vapor mixture leaves
- Requires a minimum pressure drop for proper metering



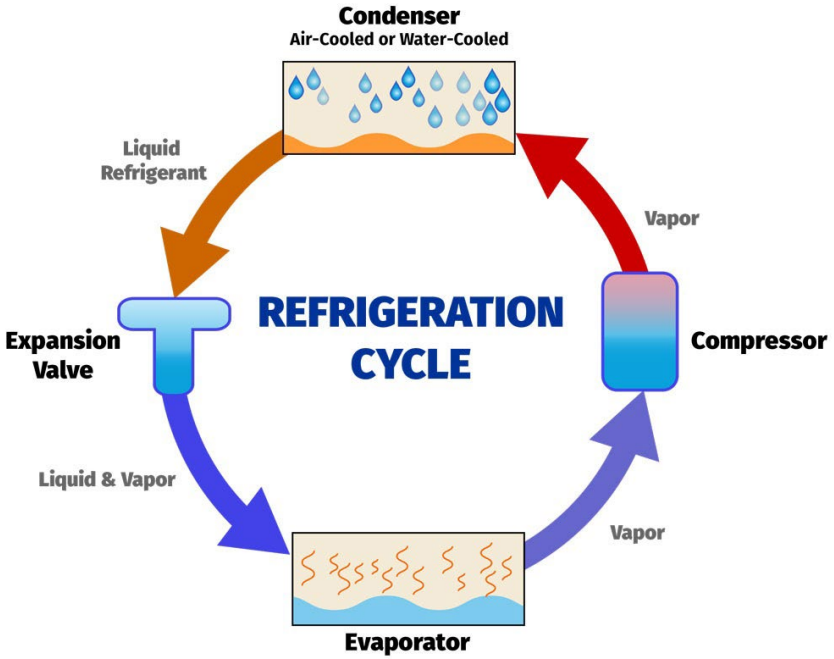
Expansion Valve - Operation

- Too much refrigerant;
  - Potential of liquid entering compressor
- Too little refrigerant;
  - Space temperature may become too warm
  - Warmer refrigerant enters compressor
- Can be thermostatic or electronic



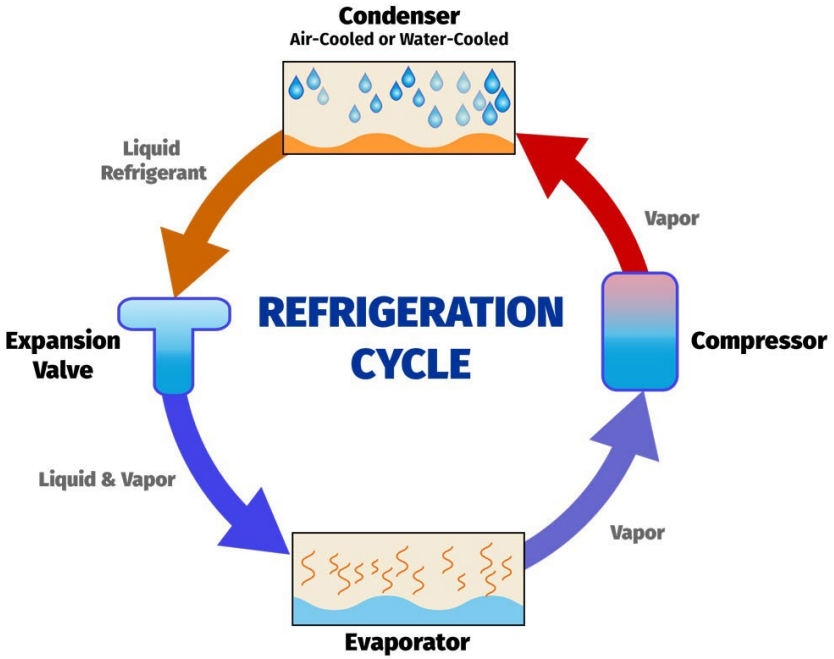


Refrigeration Cycle: Questions?



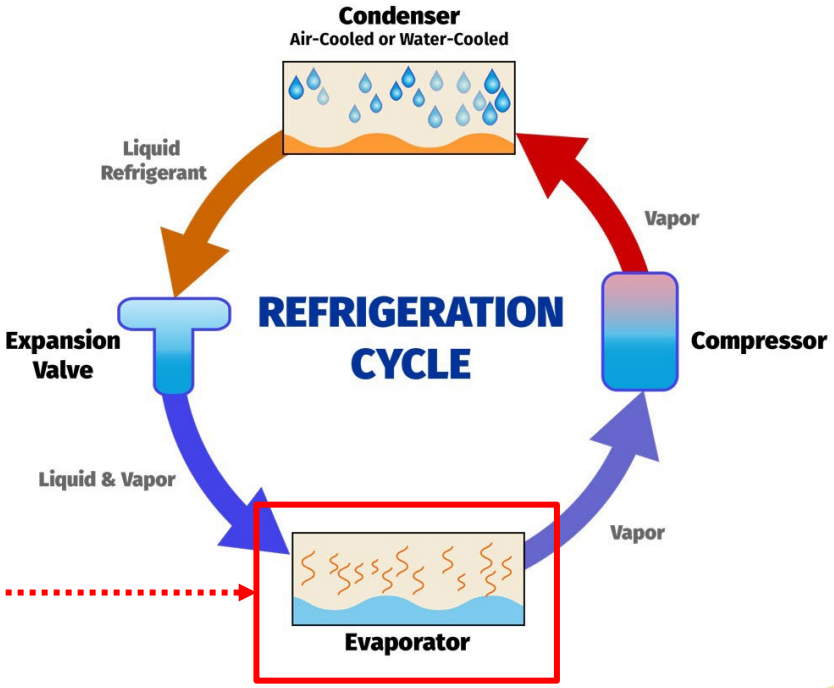
Strategies to Reduce Energy Use

- Reduce Load
- Raise Suction Pressure (aka Saturated Suction Temperature)
- Reduce Head Pressure (aka Saturated Condensing Temperature)
- Increase Component Efficiency



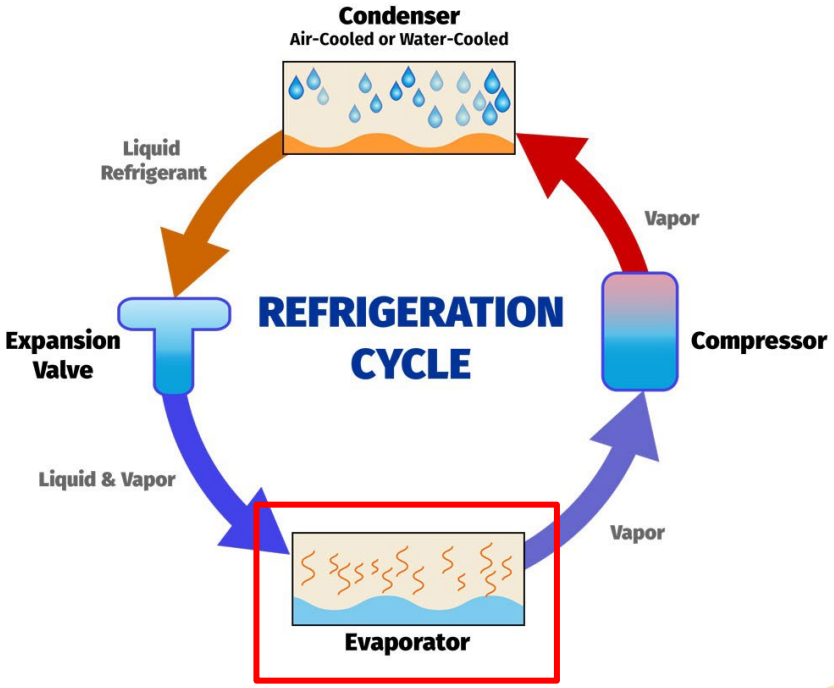
Energy Savings: Load & Evaporator Measures

- 4 Main Components
  - Evaporator
    - Increase saturated suction temperature
    - Reduce load
    - Increase component efficiency



Reducing Temperature Difference Between Load and Evaporator

- Select Low TD Evaporators
  - Tend to be larger heat exchange surface
- Flood the Evaporator Coil
  - Common in older ice areas
  - Option in new CO_2 grocery store systems



Evaporator – Component Efficiency

- Fan Motor Efficiency
  - Shaded Pole – 30%
  - Permanent Split Capacitor (PSC) – 60%
  - Electronically Commutated Motor (ECM) – 80%+
  - Permanent Magnet Motor –Eff > ECM

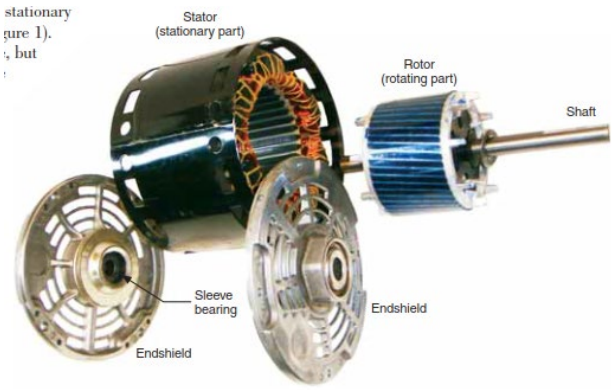


Figure 1. Typical ac induction electric motor

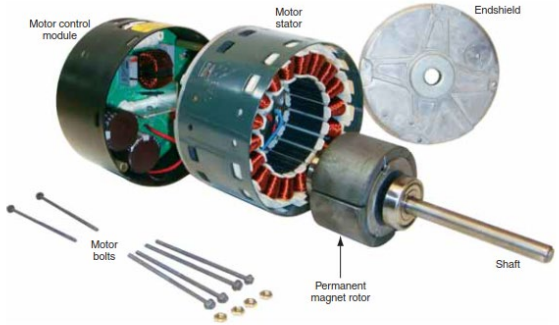
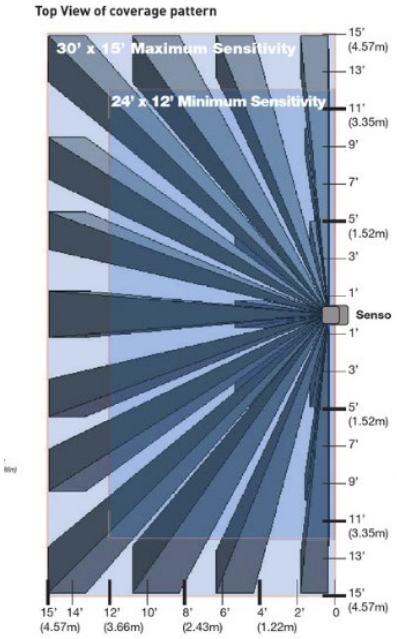


Figure 3. ECM exploded view

Grocery Store Case Lighting Controls

- Lights typically on all the time during store hours
- No means of shutting off lights
- Occupancy sensors turn lights on only when customers are near

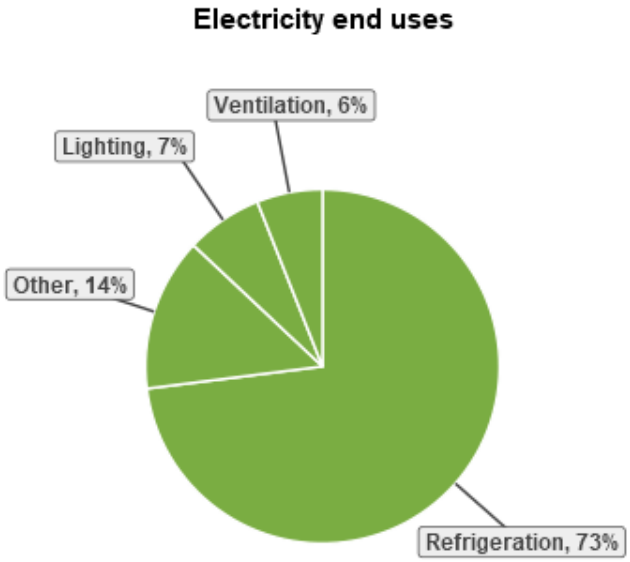


Grocery Store Case Lighting Controls

- To identify look for occupancy sensors on top of doors
- Typically installed with LED lights
  - Switching fluorescent lights on/off reduces lamp life
  - Switching LED light on/off increases lamp life

Grocery Store Case Lighting Controls

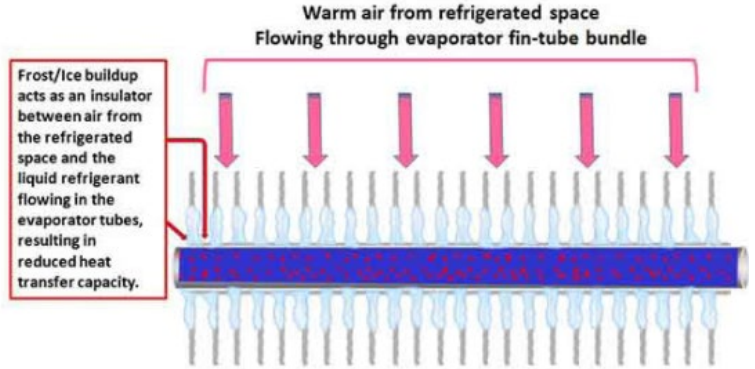
- Benefits:
  - Reduction in refrigeration load
  - Reduction in lighting energy
  - If LED lights are used:
    - Additional decrease in refrigeration load and lighting energy



Notes: May not total to 100% due to rounding. Miscellaneous is a CBECS category. Other combines end use categories < 5%: Cooking, Miscellaneous, Cooling, Computing, Heating, Office equipment.

Evaporator - Operation

- Typical refrigerant saturated suction temperature
  - Coolers: 15 to 20°F
  - Freezers: -20 to -10°F
  - 10 to 15°F temperature difference
- Fans typically operate continuously except during defrost



Evaporator Fan Cycling

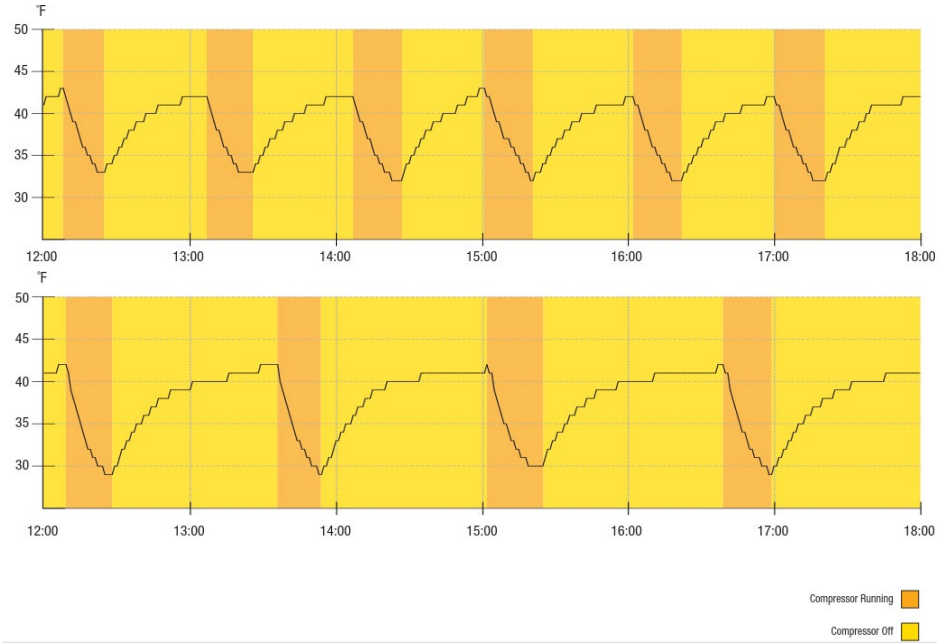
- Evaporator fans operate continuously, except during defrost
- Heat is added to space when compressors are off or valve closes
  - Compressors operate more often
- Cycling fans off or reducing speed saves both compressor and fan energy

Evaporator Fan Cycling

- Typically identified by a fan controller
- Any evaporator can implement fan cycling
- EC motor required for speed reduction in commercial systems
- VFD required for speed reduction in industrial systems

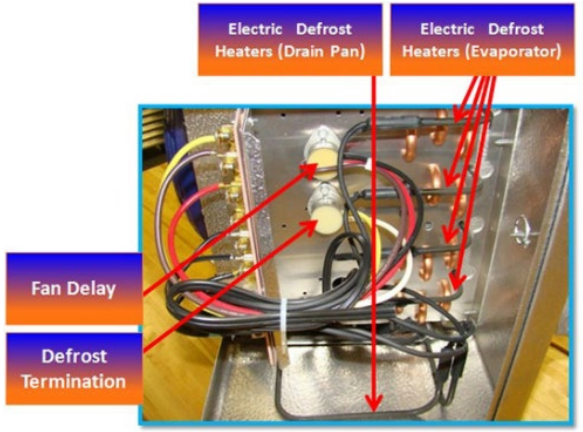
Evaporator Fan Cycling

- Benefits:
  - Reduced fan energy
  - Less heat added to space
    - Compressors operate less for split systems
    - Compressor consume less energy



Evaporator - Operation

- Defrost Cycles
  - Off Time – Uses air from space
    - Coolers only
  - Electric – Resistance heating rods inserted along coil
  - Hot Gas – Refrigerant discharge vapor from compressor
- Defrost cycles are typically scheduled and time based



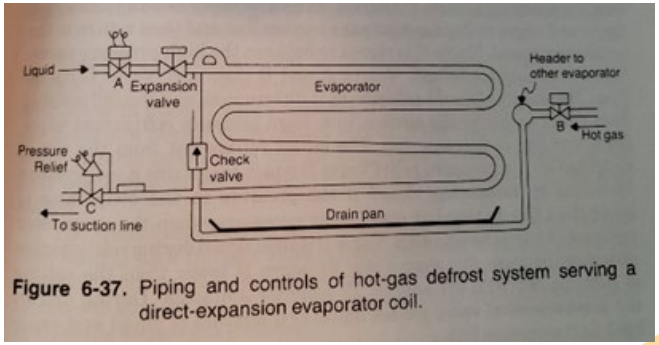
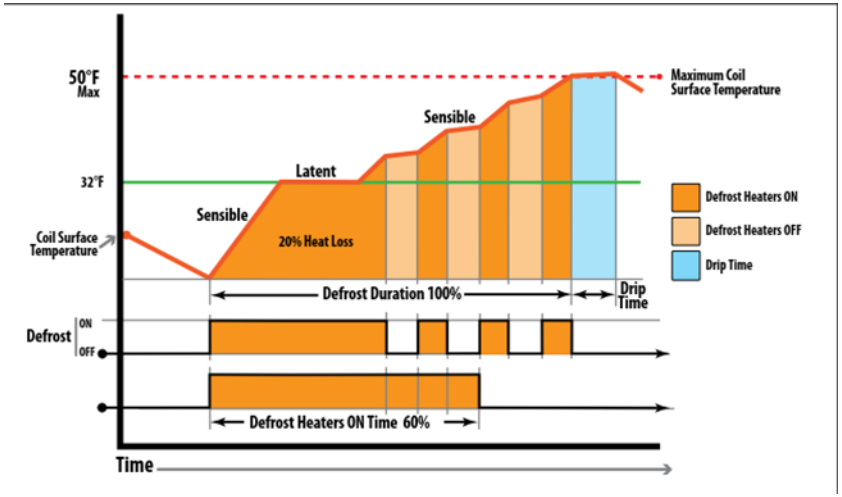


Figure 6-37. Piping and controls of hot-gas defrost system serving a direct-expansion evaporator coil.

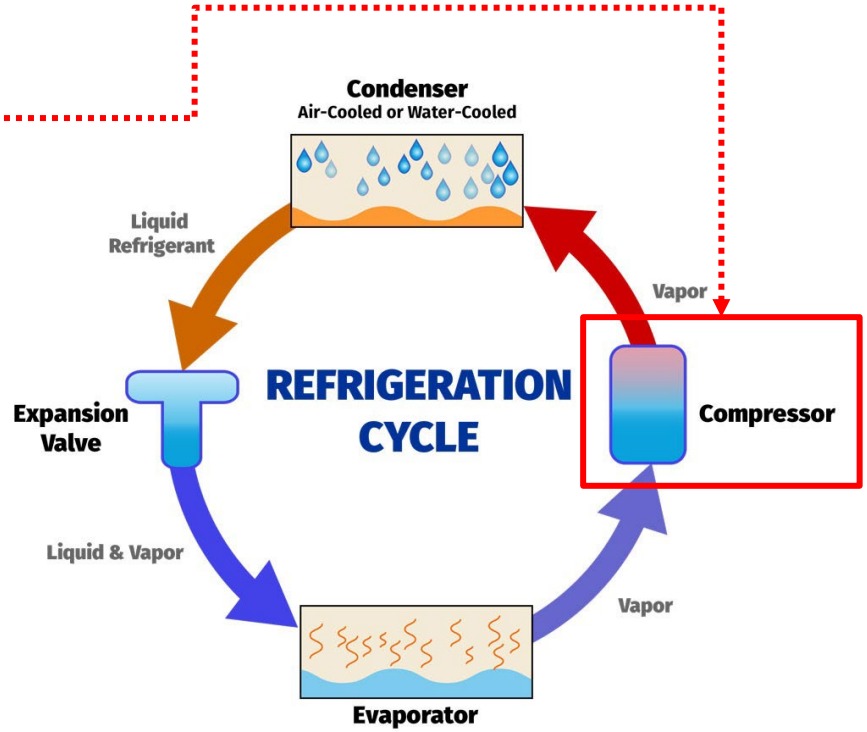
Improved Freezer Defrost Control

- Benefits:
  - Eliminates unneeded cycles
  - Reduces heat generated into space and compressor energy
  - Reduces energy consumed from electric heaters
  - More consistent product/space temperatures



Energy Savings: Compressor Measures

- 4 Main Components
  - Compressor
    - Increase saturated suction temperature
    - Increase part-load component efficiency



Compressor Savings in Grocery Stores

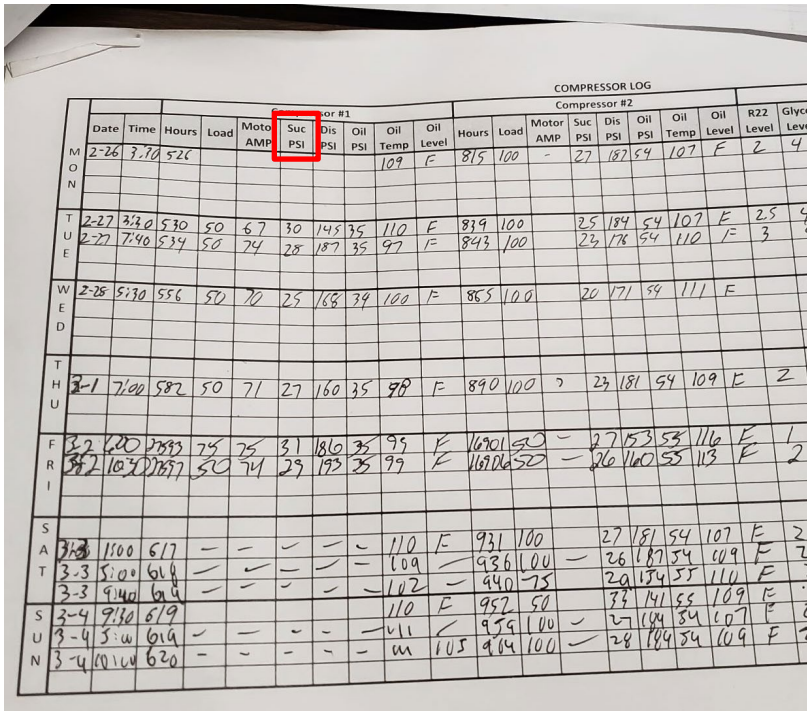
- Floating suction pressure control
  - Fixed schedule if night covers, etc.
  - Based on temperature feedback
- Compressor part-load control
  - Compressor efficiency
  - Increase average suction pressure

Raise Suction Pressure, Ice/Glycol Temperature

- Increases starting point of compressors “uphill climb”
- Compressor power increases slightly but operates more efficiently with more capacity
- For Grocery/Industrial, setpoint dictated by lowest evaporator temperature required
- For ice arenas, setpoint is based on ice and glycol temperature

Raise Suction Pressure, Ice/Glycol Temperature

- How to identify suction pressure setpoint
  - Can be found on compressor logs
- If constant, there are multiple ways to increase setpoint;
  - Increase fixed setpoint
  - Schedule or float setpoint to increase during low load periods
  - Regroup evaporator loads more efficiently



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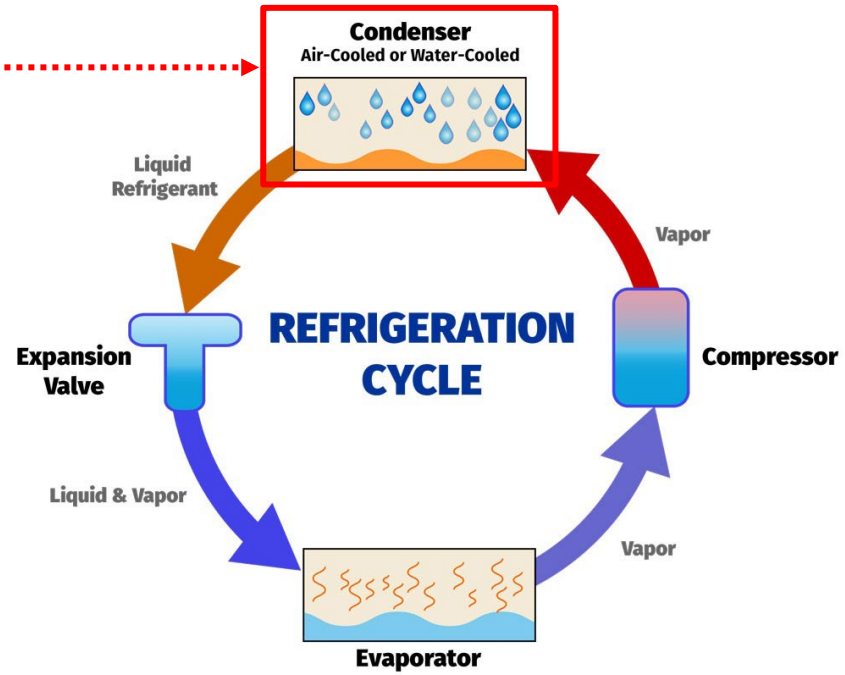
Raise Suction Pressure, Ice/Glycol Temperature

- Benefits:
  - Increases compressor efficiency
    - Consumes less energy annually
    - Reduced number of run hours
  - Compressor refrigeration capacity increases

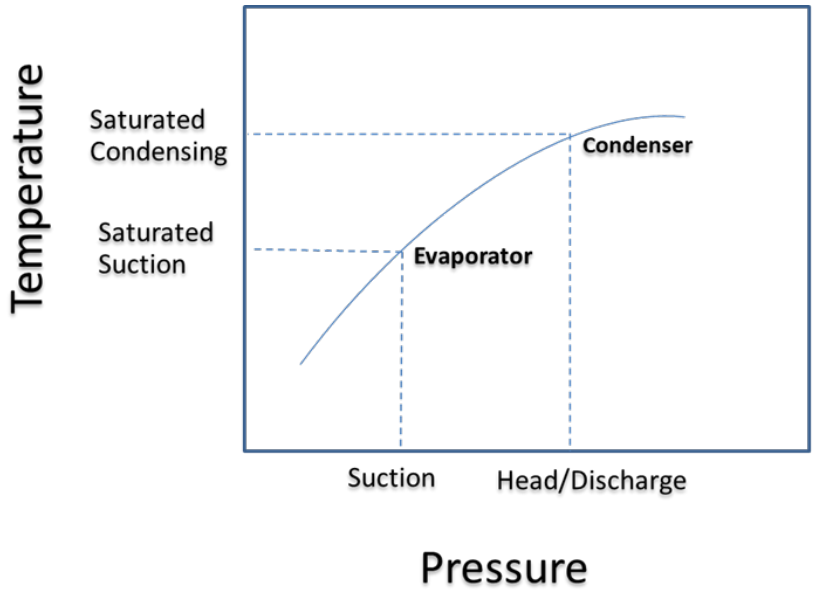
Energy Savings: Condenser Measures

- 4 Main Components
  - Condenser
    - Reduce head pressure
    - Improve component efficiency



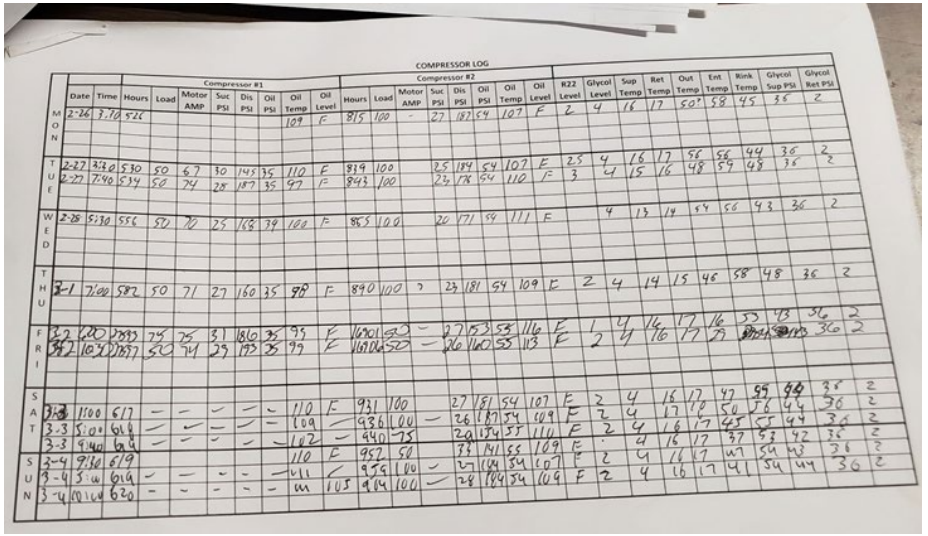
Reduce Minimum Head Pressure

- Reduces minimum head pressure condenser is trying to maintain
- Lowers amount of compressor “uphill climb”
  - Compressor work is reduced
- Often set high due to min. required pressure drop of expansion valve
- Must know current minimum head pressure and pressure drop across expansion valve



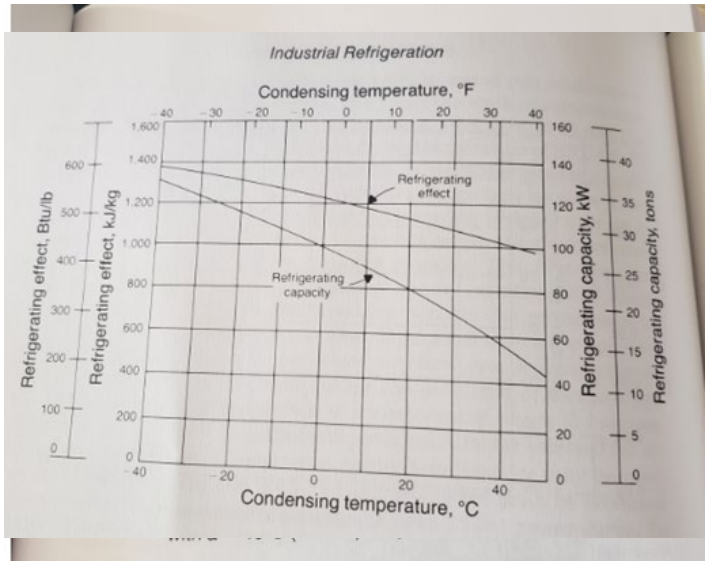
Reduce Minimum Head Pressure

- How to identify min. head pressure setpoint
  - Locate condenser control panel and cut out pressure switch or system controller
  - Compressor logs
- Verify minimum required pressure drop of existing expansion valve
- Contact contractor to assist in verifying current setpoint and making changes



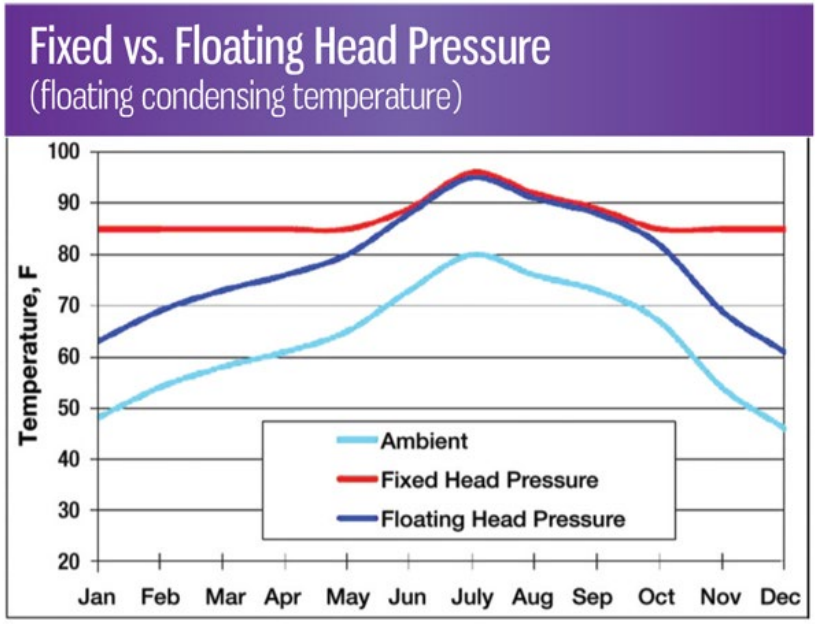
Reduce Minimum Head Pressure

- Benefits:
  - Reduction in compressor energy consumption
  - Refrigeration capacity of compressor increases
  - Condenser fans may not cycle as often



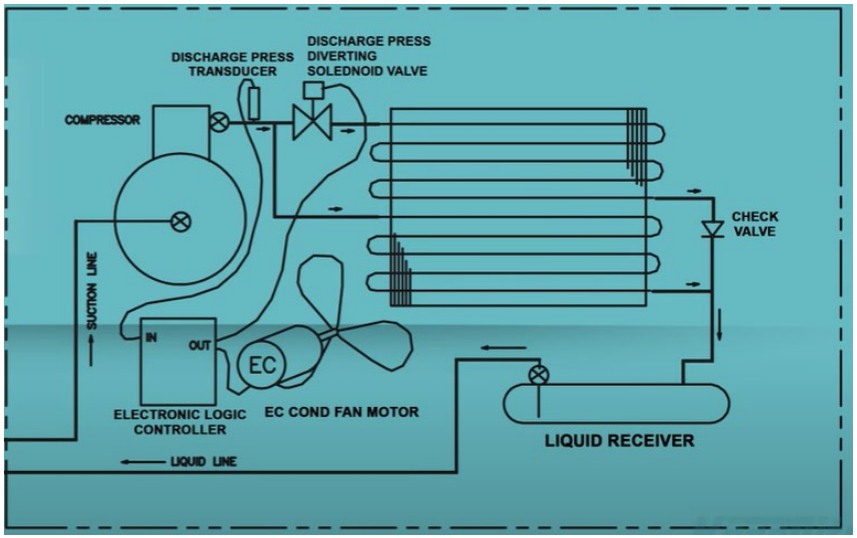
Ambient Approach Control of Condenser

- Min. head pressure setpoint typically constant
  - Often set higher than required
- Condensers selected for design delta T
  - 15F – Medium Temp
  - 10F – Low Temp
- Ambient approach control maintains this delta T



Ambient Approach Control of Condenser

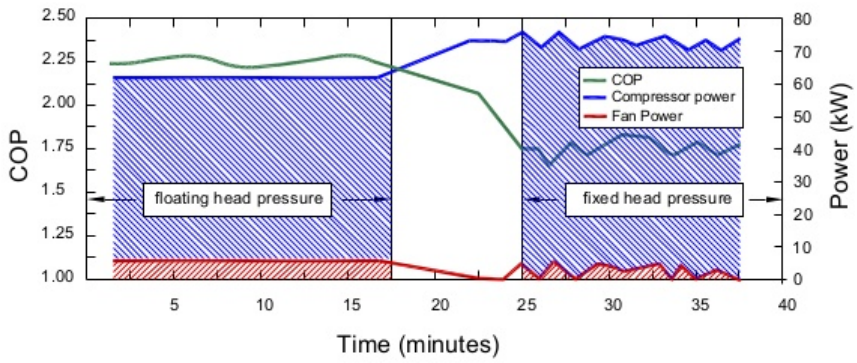
- Capability often present but not used
- Requires logic controller
- Head pressure is reset to maintain the design delta T with outside conditions
  - Air Cooled – Outside Temperature
  - Adiabatic – Outside temperature after being precooled
  - Evaporative – Outside moisture content
- Limited by system minimum



Ambient Approach Control of Condenser

- Benefits:
  - Smaller hill for compressors to climb
    - Compressors consume less energy
  - Improved performance at lower outside air temperatures
    - Consistent head pressures
  - Can be combined with Reduced Min. Head Pressure and Condenser VFD measures for further energy savings

Measured COP, compressor power and fan power
for floating and fixed head pressure control
[ASHRAE JOURNAL]

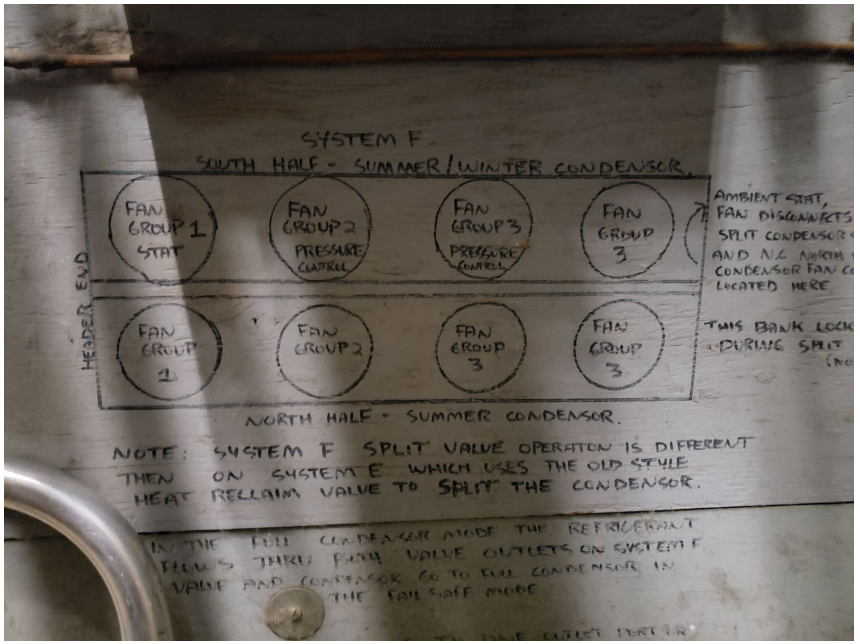


Condenser Types – Air Cooled

- Ambient air is blown over condenser coils by axial fans
- Single or double fan banks
- Three different fan speeds available
  - 540 RPM
  - 830 RPM
  - 1140 RPM
  - 1140 RPM, ECM
- Lowest first cost
- Simplest to operate
- Typically highest system energy consumption

Condenser Types – Air Cooled Operation

- Fans are controlled to maintain a minimum condenser/head pressure
  - Fans stage on/off or modulate as pressure rises/falls
  - ECM's and VFD's provide more consistent condenser pressures
  - Minimum condenser pressure typically fixed



Low Speed Condenser Fans

- General speeds available:
  - 540 RPM
  - 830 RPM
  - 1140 RPM (ECM option)
- Condenser input energy increases at higher fan speeds
- Efficiency improves at lower fan speeds

Condenser Info. Summary @ 60 Ton Refrigeration Load, Medium Temp				
Condenser Inputs	**Baseline, 1140 RPM**	**1140 RPM, ECM**	**830 RPM**	**540 RPM**
Mfg. / Model	Russell, RDD-075	Russell, RDD-075	Russell, RDD-080	Russell, RDD-080
Fan Speed (RPM)	1140	1140	830	540
Fan Configuration	2x4	2x4	2x5	2x6
# of Fans	8	8	10	12
Fan Motor HP	1.5	2	1	0.333
Condenser kW Input	14.4	17.6	9	4.2
Condenser Efficiency (BTUH/Total HP)	184967	145438	238460	574600

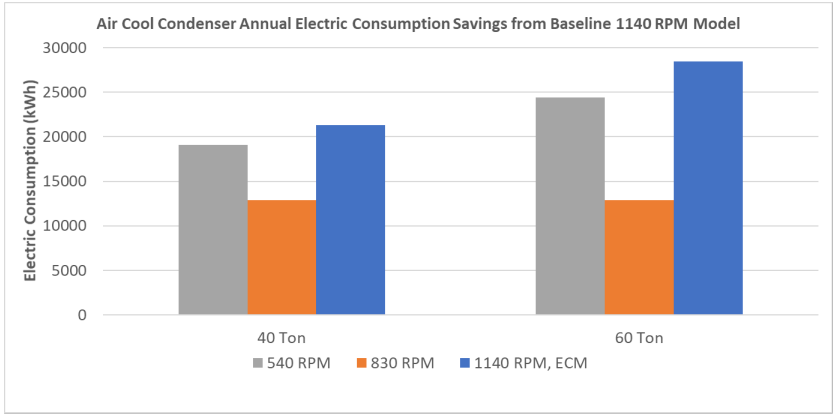
Low Speed Condenser Fans

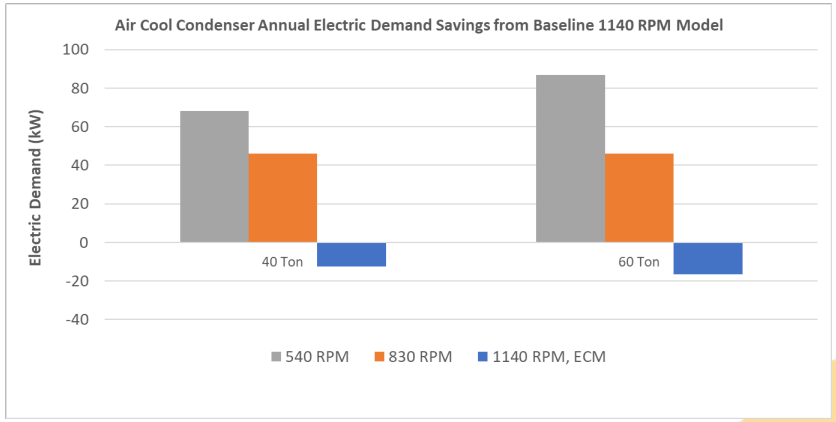
- Higher speed models generally selected due to smaller footprint and lower first cost
- 540 rpm models provide the largest energy savings

Energy Cost Analysis of Baseline 1140 RPM Air Cool Condenser							
Motor Speed	Average Payback	Design Refrigeration Load (Tons)					
		60			40		
		First Cost	Annual Energy Cost Savings	Payback	First Cost	Annual Energy Cost Savings	Payback
1140 RPM	-	$32,663.40	-	-	$23,466	-	-
540 RPM	4.6	$50,390.90	$ 3,792.65	4.7	$36,476	$ 2,821.47	4.6
1140 RPM, ECM	6.1	$50,100.75	$ 2,739.49	6.4	$36,570	$ 2,279.28	5.7
830 RPM, 1 HP	4.2	$41,023.15	$ 1,660.79	4.8	$27,154	$ 1,099.18	3.6

Low Speed Condenser Fans

- Benefits:
  - Lower electric demand costs
    - ECM and VFD's can't achieve these demand savings
  - Electric consumption savings
  - Higher condenser efficiency





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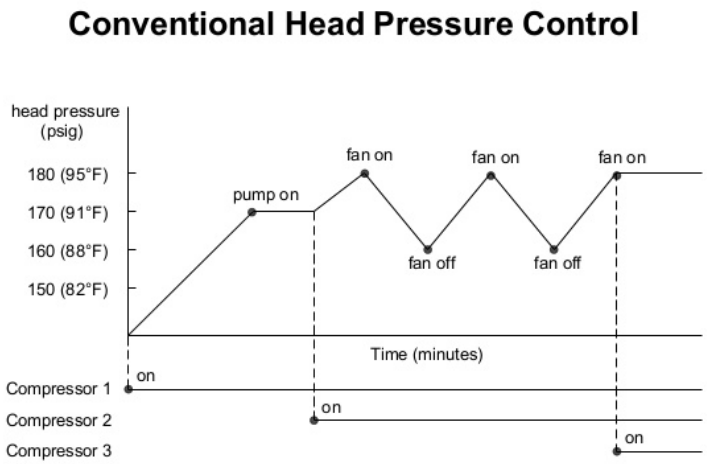
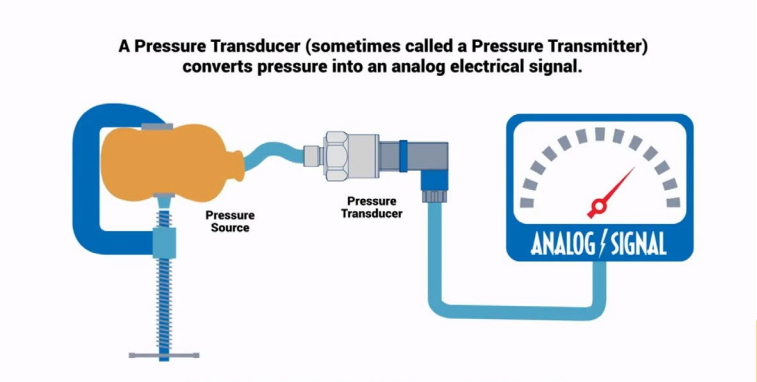
Condenser Fan VFD Control

- Three ways to control condenser fans:
  - On/Off
  - Two Speed
  - Variable Speed
- Fan control can be a mix of operation
  - Stage most fans on/off with 1 or 2 variable speed fans
- Applies to all types of condensers



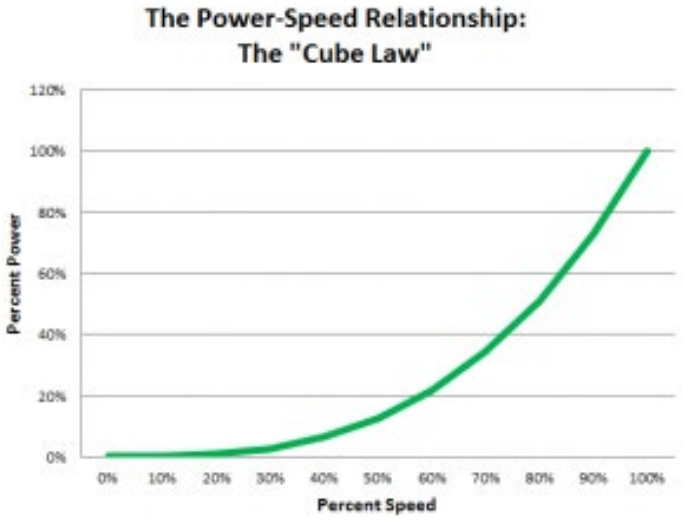
Condenser Fan VFD Control

- Implemented by installing a VFD
  - VFD's are an option for new and existing condensers
  - Generally, need 3 phase motor for a VFD
  - Pressure transducer required to control fans



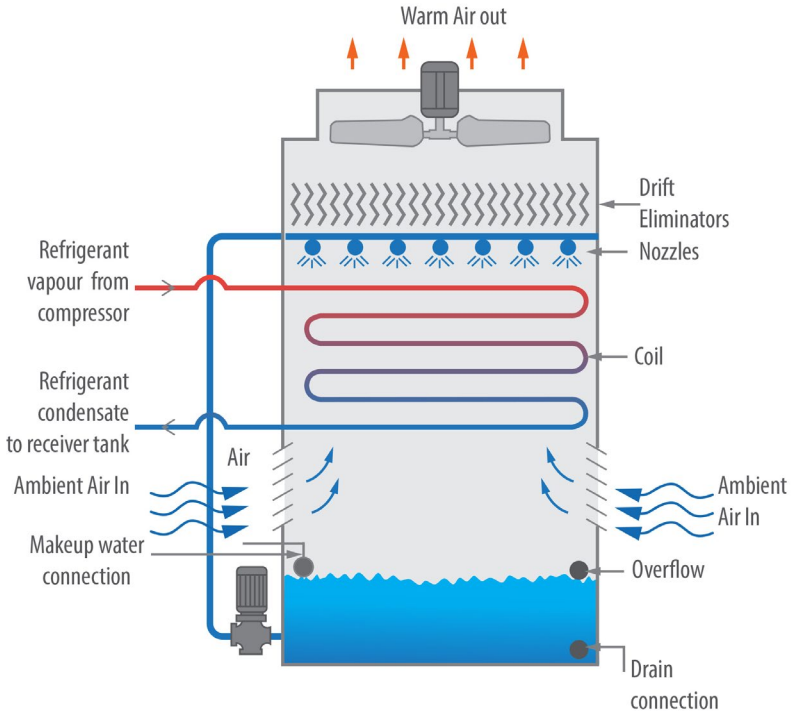
Condenser Fan VFD Control

- Benefits:
  - Reduction in fan energy consumption
  - Less fan cycling
  - Stable head pressure
  - Reduced sound at lower fan speeds
  - Evaporative condensers save energy by optimizing control of fans and pump
    - Reduces water scaling



Condenser Types – Evaporative

- Uses evaporation to cool, condense the refrigerant
- Water is sprayed over condenser coil
- Water evaporates into air blown over coils, removing heat from refrigerant
- Multiple Types:
  - Induced draft axial fan
  - Forced draft axial fan
  - Centrifugal fan

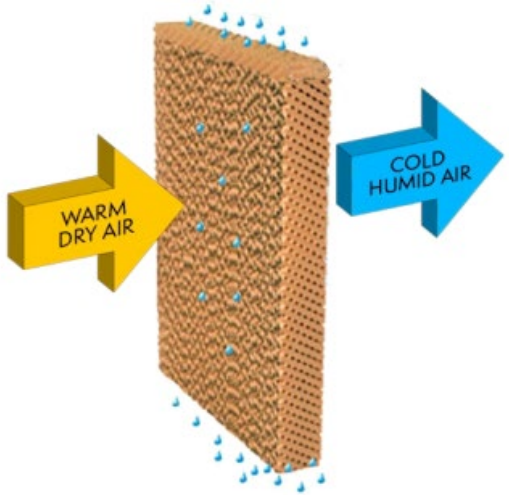


Condenser Types – Evaporative Operation

- Dryer air = more heat removed
- Highest condenser saturation temp. is 95°F
- Water continuously sprayed for most of the year
  - Dry operation reduces capacity
- Fans stage on/off or modulate (VFD) to maintain min. head pressure
- In cold climates, spray water sump located indoors

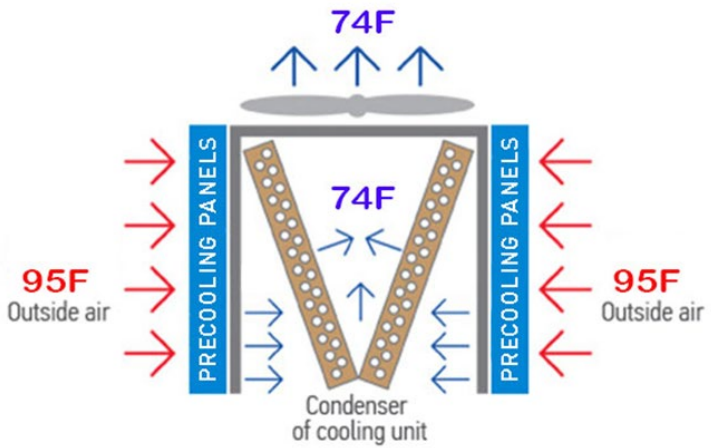
Condenser Types – Adiabatic

- Similar to air cooled condensers
- Cooling pads, saturated with water, cools entering outside air
  - Water evaporates into air, cooling it
  - Dryer air absorbs more water and is cooled more
- Lower outside air temperature = Lower condenser saturation temperature



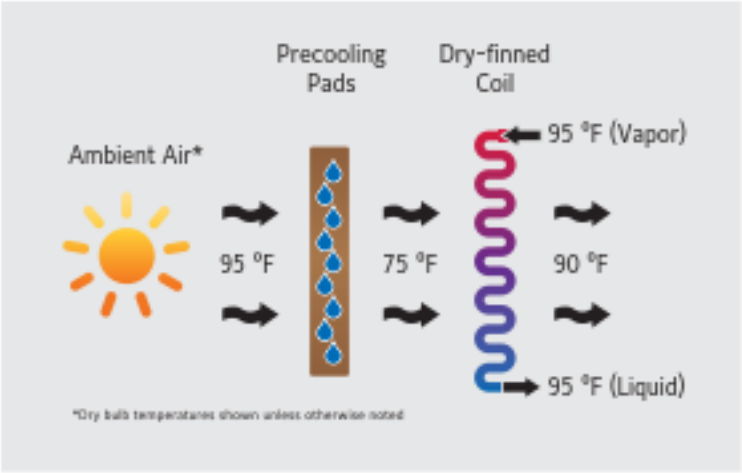
Condenser Types – Adiabatic Operation

- Similar fan operation to air cooled
- Small pump used to keep pads saturated
  - Can be circulated or once through
- Highest condenser saturation temperature is commonly 95°F
- Can operate dry when outside air temp becomes low enough



Adiabatic Condensers

- Similar operation to air cooled but can reduce temperature of outdoor air
  - Reduces required condenser saturation temperature
  - Critical during peak operating conditions
- Can operate dry during mild weather conditions

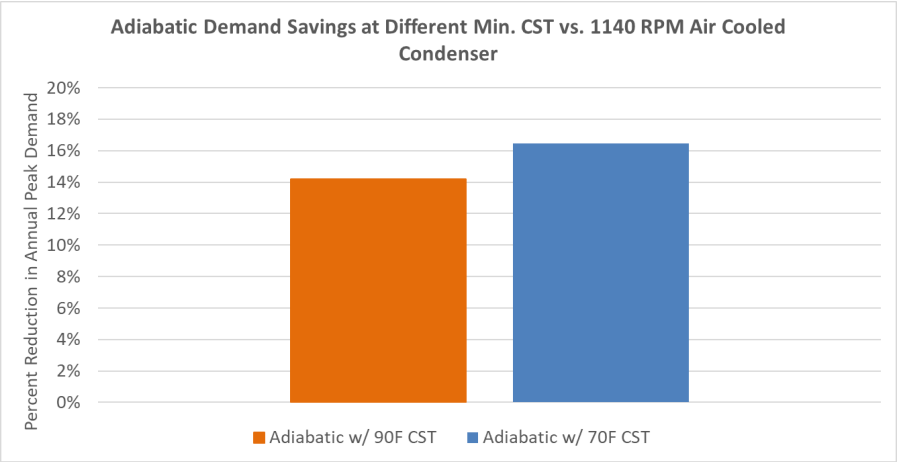


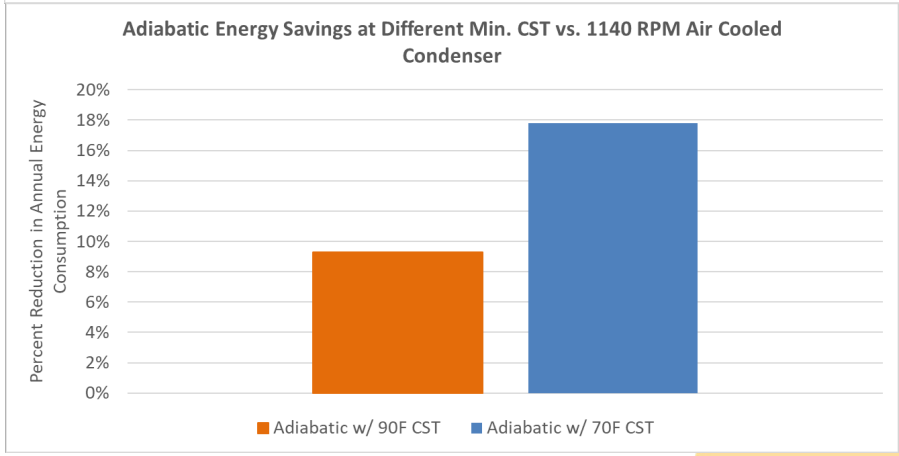
Adiabatic Condensers

- How to distinguish:
  - Precooling pads on sides
  - Typically more compact, smaller footprint
  - Water pump for pads
    - Water can be circulated or once through
    - If circulated, usually replaced regularly to avoid contamination

Adiabatic Condensers

- Benefits:
  - Electric demand savings
  - Consume less energy
    - Depends greatly on controls/operation
    - Lower condenser saturation temperature = less energy consumed overall





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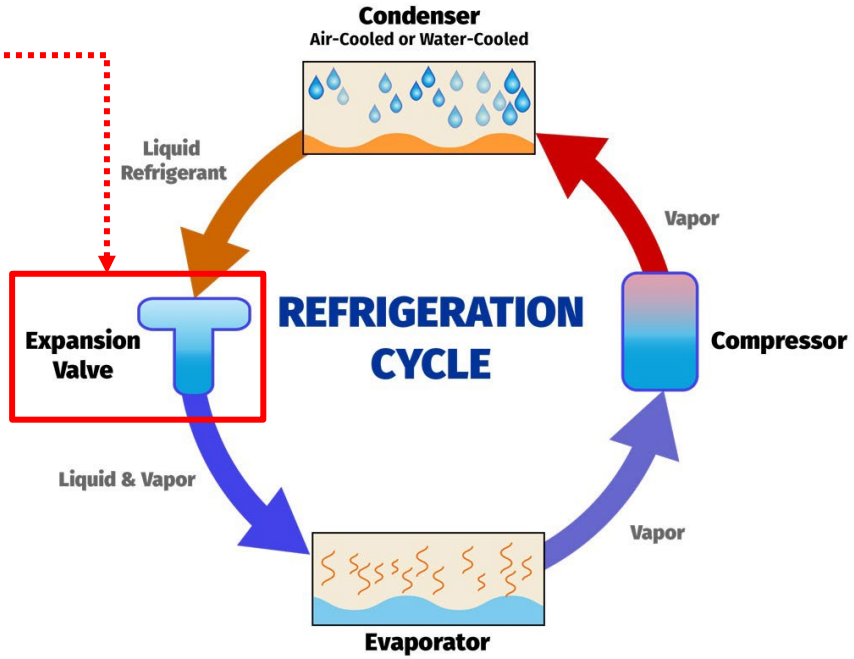
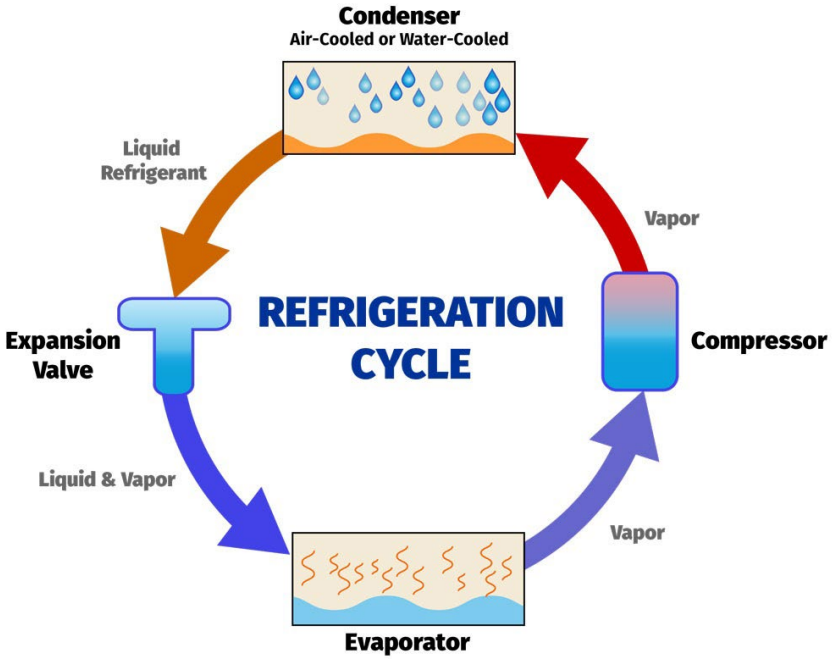
Energy Savings: Expansion Valves

- 4 Main Components
  - Expansion Valve
    - EEV Allow for lower head pressures
    - Better superheat control allows for higher evaporator temperatures



Strategies to Reduce Energy Use

- Reduce Load
- Raise Suction Pressure (aka Saturated Suction Temperature)
- Reduce Head Pressure (aka Saturated Condensing Temperature)
- Increase Component Efficiency

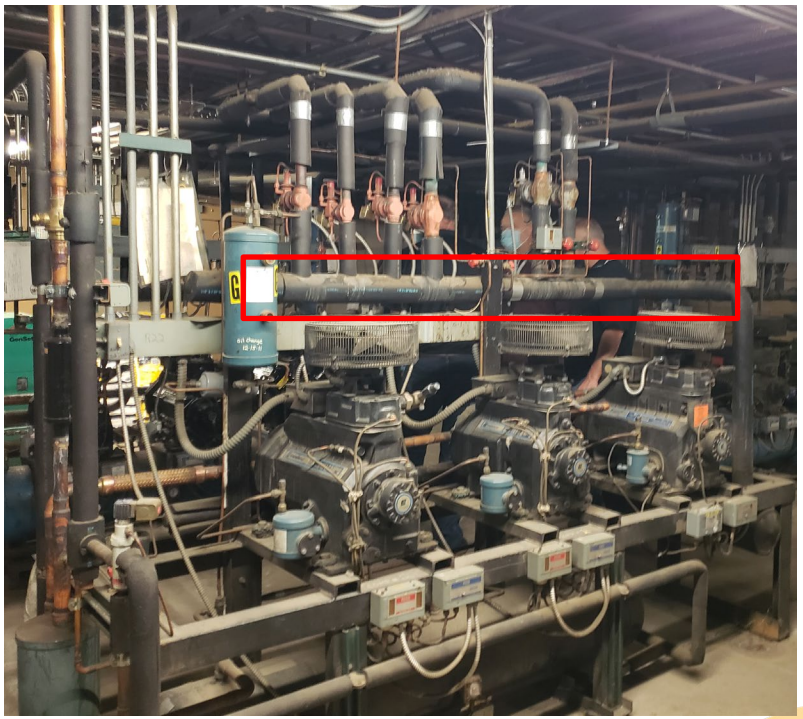


Equipment Upgrades and Retrofits

- Ottertail Power
  Qualifying equipment
  and Rebates

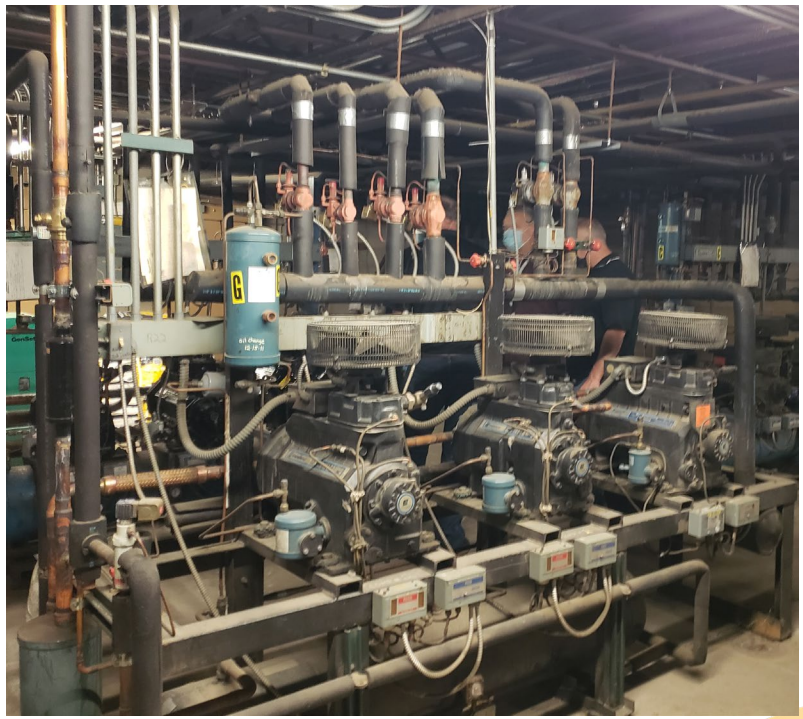
Parallel Rack (Retrofit)

- Converts existing stand-alone compressors into rack system
- Grouped compressors share a common suction pressure
  - Common suction/discharge piping
- Grouped based on low/medium temp. categories



Parallel Rack (Retrofit)

- Rebate Requirements:
  - Minimum of 3 compressors
  - Range of evaporator saturated suction temperatures must be no more than 8°F
  - Floating head pressure control required
    - Additional rebate for implementing this control
  - Rebate = $100 per compressor hp



Parallel Rack (Retrofit)

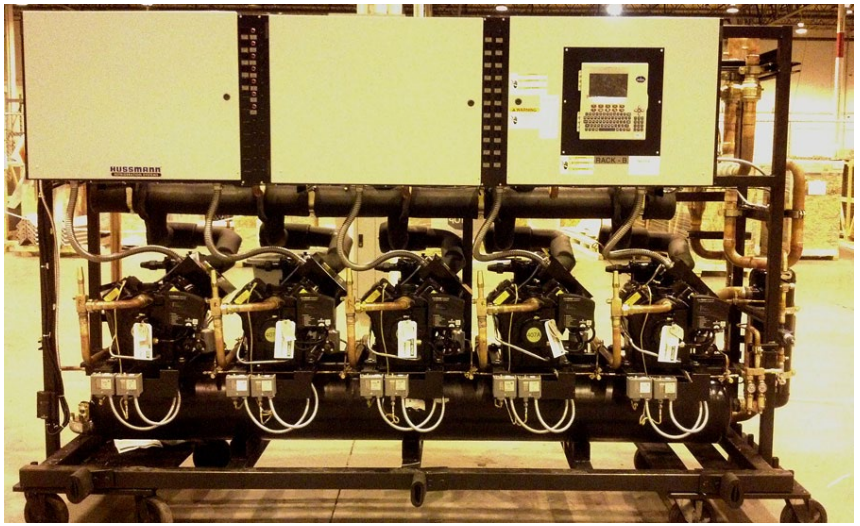
- Benefits:
  - Closer matched compressor capacity to evaporator capacity
    - Provides higher avg. suction pressures and lower avg. head pressures
  - More consistent saturated suction temperatures
  - Floating head pressure reduces compressor uphill climb
    - Reduces energy consumption of compressors

Conversion to Solid-State Compressor Controls (Retrofit)

- Older compressors controlled by mechanical pressure switches
  - Inefficient and don't respond quickly to system changes
- Solid-state = electronic
- Varies combination of compressors to match refrigeration load

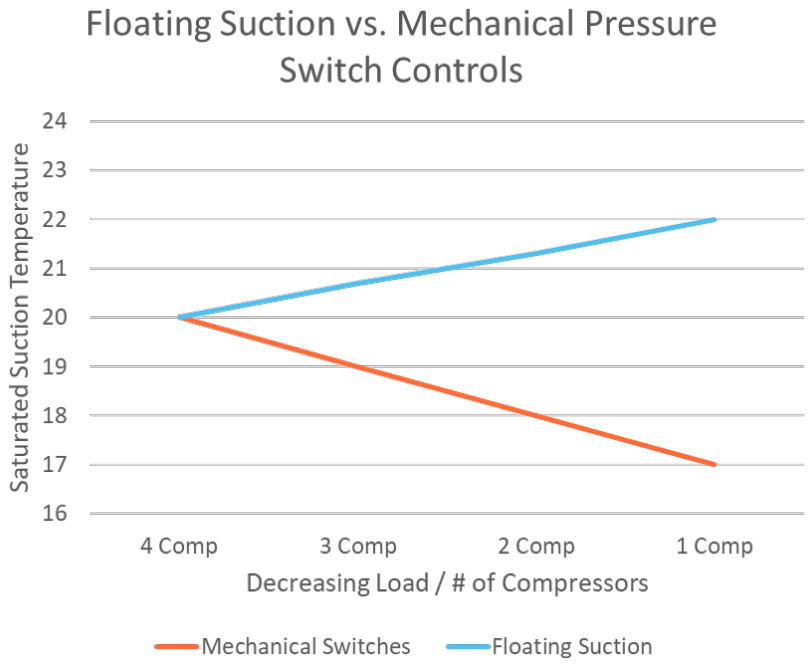
Conversion to Solid-State Compressor Controls (Retrofit)

- Rebate Requirements:
  - Min. 3 compressors on rack
  - Controller optimally matches compressor capacity with refrigeration load
  - Use suction pressure or case temperature for sensing load



Conversion to Solid-State Compressor Controls (Retrofit)

- Rebate Requirements:
  - Implement floating suction pressure control
  - Single suction pressure setpoint control
  - Implement floating head pressure control
    - Additional rebate only if existing controls didn't have floating capability
- Rebate = $50 per compressor hp



Conversion to Solid-State Compressor Controls (Retrofit)

- Benefits:
  - High compressor efficiencies
    - Less compressor energy consumed
  - Consistent suction pressures
    - Compressors respond better to refrigeration load changes
  - More reliable controls

Solid State Condenser Fan Controls (Retrofit)

- Replaces mechanical pressure switch controls to electronic
  - Inefficient and don't respond quickly to system changes
- Condenser fans controlled to efficiently maintain head pressure
- More energy savings if implemented with any of the following;
  - Condenser fan VFD control
  - Floating head pressure
  - Ambient approach control

Solid State Condenser Fan Controls (Retrofit)

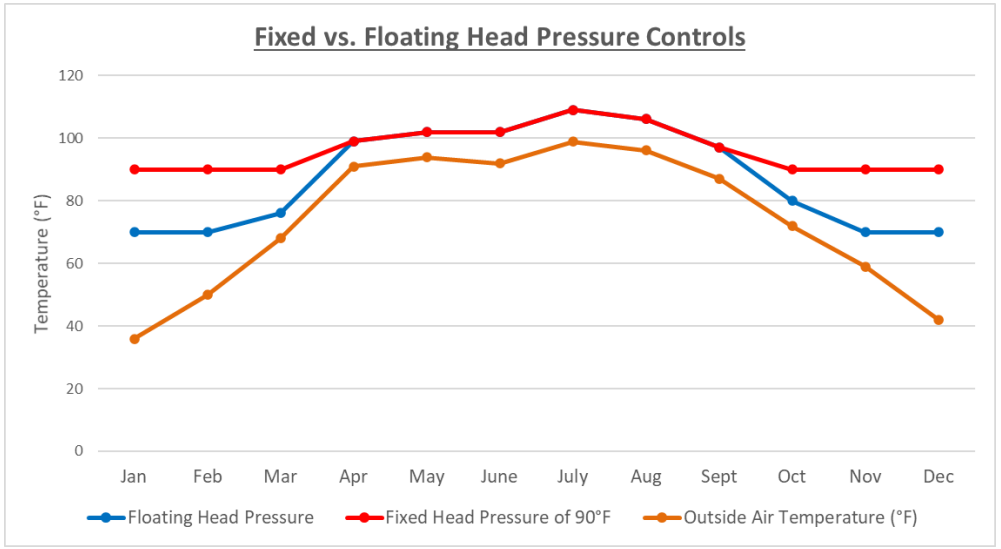
- Rebate Requirements:
  - Minimum of three fans on condenser
  - Each fan controlled individually
    - Exception if using VFD to control multiple small fans
  - Brief written description of potential energy savings
    - Compares existing and new control schemes
- Rebate = $50 per compressor hp

Solid State Condenser Fan Controls (Retrofit)

- Benefits:
  - Reduction in fan energy consumption
    - Potential to reduce compressor energy
  - Consistent head pressures
    - Fans respond better to system changes
  - More reliable controls

Floating Head Pressure Control on Rack (Retrofit)

- Condenser saturation temperature can float down as outside air temperature decreases
- Applies to existing central refrigeration systems with compressor racks
- Similar to Reduced Min. Head Pressure measure

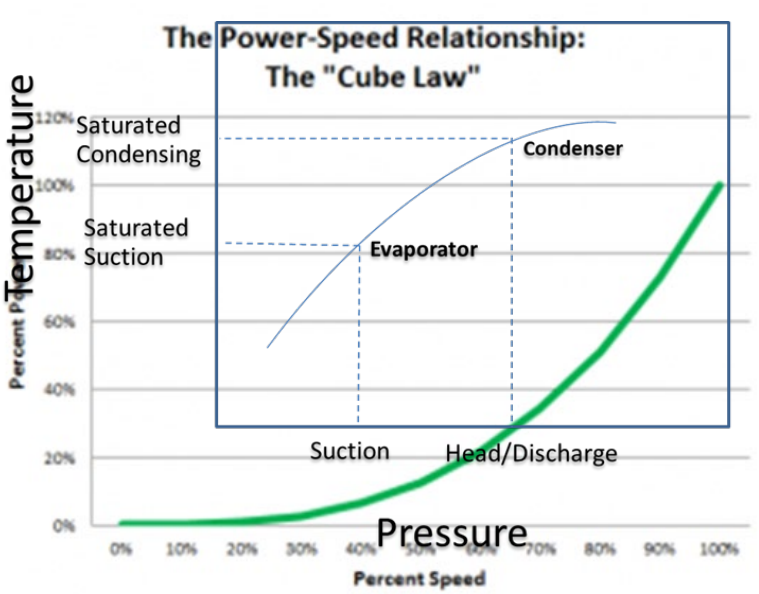


Floating Head Pressure Control on Rack (Retrofit)

- Rebate Requirements:
  - Float down to 70°F min.
  - Liquid lines from condenser must be insulated
  - Subcooling implemented
    - Additional measure/rebate
  - Condenser is outdoors
  - Signed statement from qualified refrigeration contractor verifying system can float head pressure
- Rebate = $25 per compressor hp

Floating Head Pressure Control on Rack (Retrofit)

- Benefits:
  - Smaller hill for compressors to climb
    - Compressors consume less energy
  - Improved performance at lower outside air temperatures
    - Consistent head pressures
  - Can be combined with Condenser Fan VFD Control measure for further energy savings



Floating Head Pressure, Standalone (New & Retrofit)

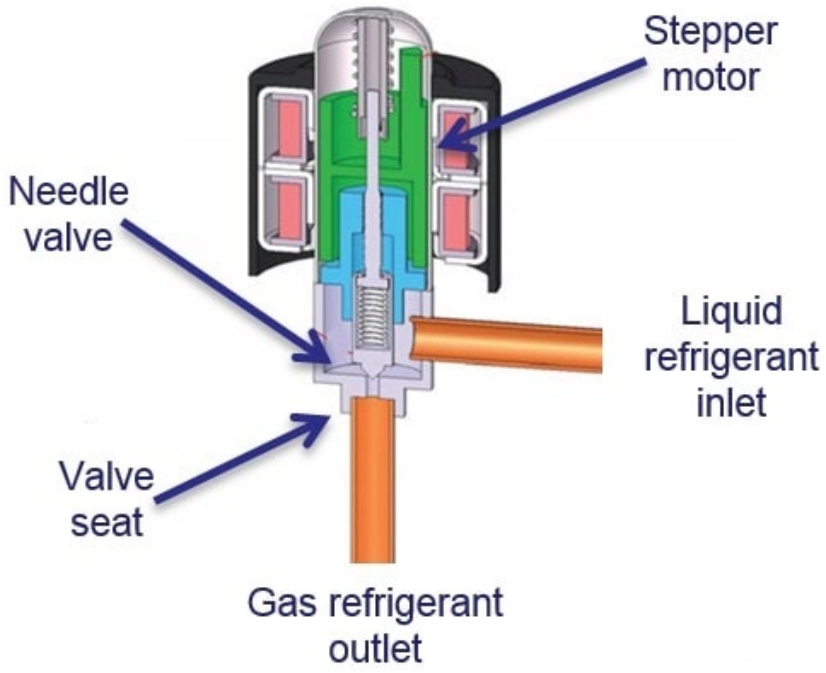
- Applies to new and existing split system condensing units
- Typically have constant min. head pressure setpoint
  - Normally set high
- Similar to Reduced Min. Head Pressure measure

Floating Head Pressure, Standalone (New & Retrofit)

- Rebate Requirements:
  - Float down to 75°F minimum
  - Controls ensure fans only operate as needed once at its minimum condenser saturation temperature
  - Liquid lines from condenser must be insulated
    - Subcooling implemented
      - Additional measure/rebate
    - Condenser is outdoors
    - Signed statement from qualified refrigeration contractor verifying system can float head pressure
- Rebate = $60 per compressor hp

Floating Head Pressure, Standalone (New & Retrofit)

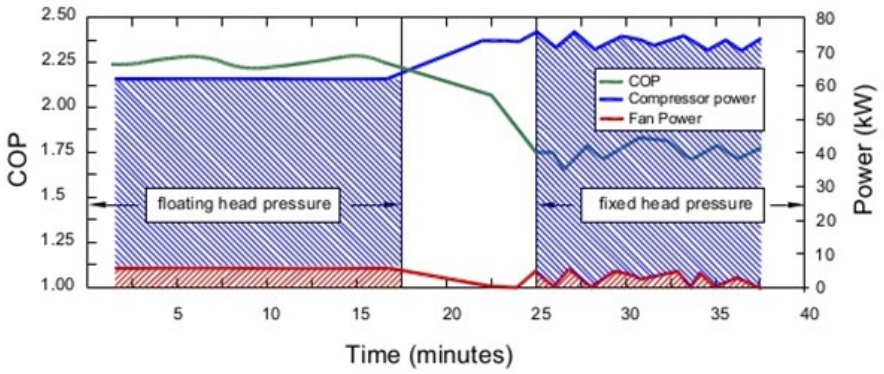
- Rebate Requirements:
  - New facilities
    - Must ensure adequate refrigerant is metered to evaporators at low head pressures
      - Electronic expansion valves or other strategies



Floating Head Pressure, Standalone (New & Retrofit)

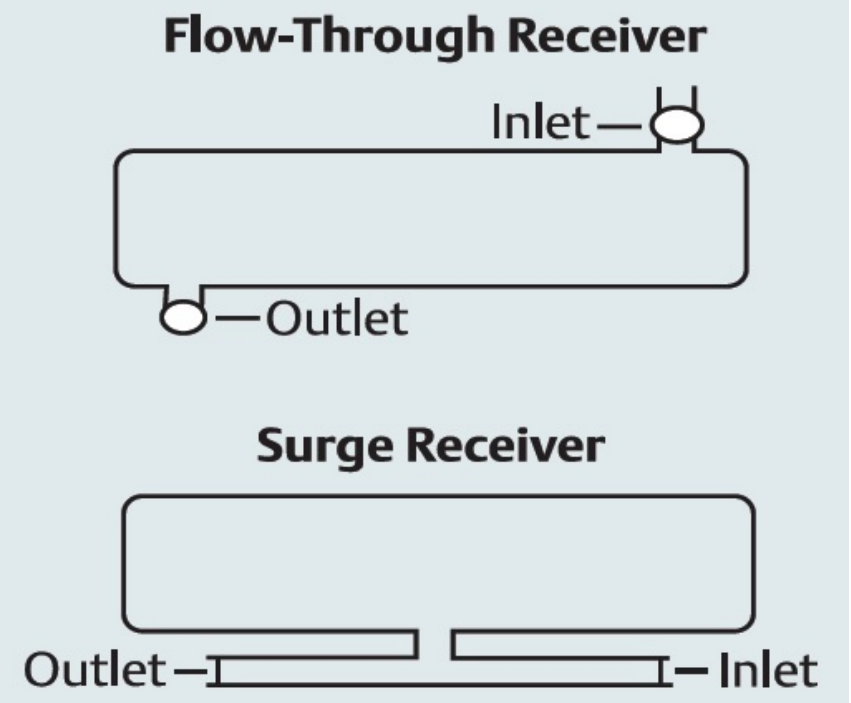
- Benefits:
  - Smaller hill for compressors to climb
    - Compressors consume less energy
  - Improved performance and efficiency at lower outside air temperatures
    - Consistent head pressures

Measured COP, compressor power and fan power for floating and fixed head pressure control
[ASHRAE JOURNAL]



Preservation of Condenser Subcooling (Retrofit)

- Refrigerant continues to cool in condenser after changing from vapor to liquid
- More subcooling = more heat absorbed at evaporator
- Liquid refrigerant spends too long in flow-through receiver
  - Refrigerant temperature increases

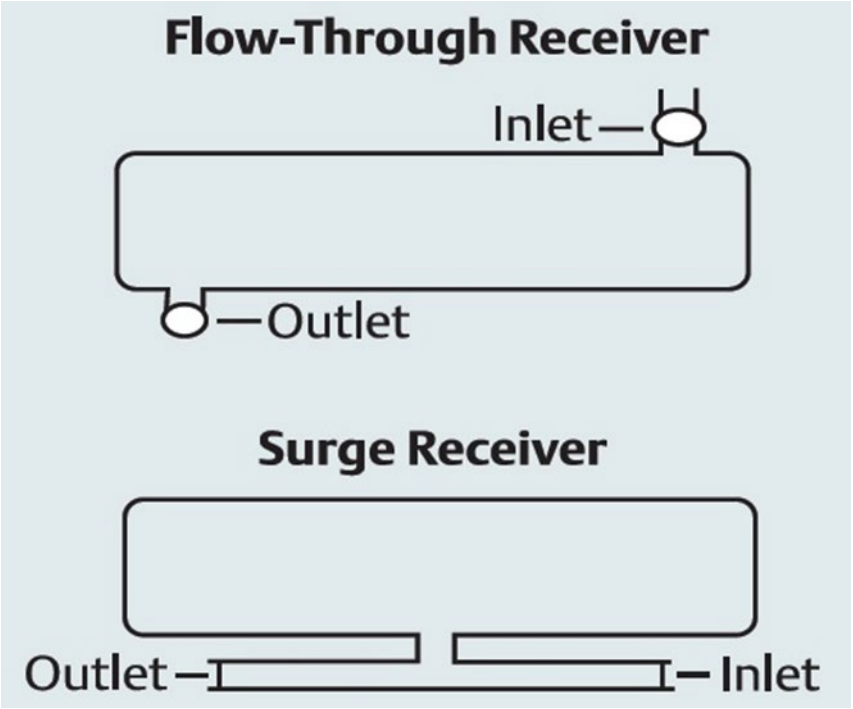


Preservation of Condenser Subcooling (Retrofit)

- Rebate Requirements:
  - Surge receiver preferred method
    - Other options considered on case-by-case basis
  - Min. 2/3 of subcooling reaches liquid lines to evaporators
    - Includes during winter conditions
- Rebate = $40 per compressor hp

Preservation of Condenser Subcooling (Retrofit)

- Benefits:
  - Increases amount of heat evaporators can absorb
  - System efficiency increases



High Efficiency Evaporator Fan Motor (New & Retrofit)

- Standard motor type is Shaded Pole (SP)
  - SP Efficiency ≈ 30%
- High efficiency motors
  - Permanent Split Capacitor (PSC)
    - PSC Efficiency ≈ 60%
  - Electronically Commutated Motors (ECM)
    - ECM ≈ 80%+

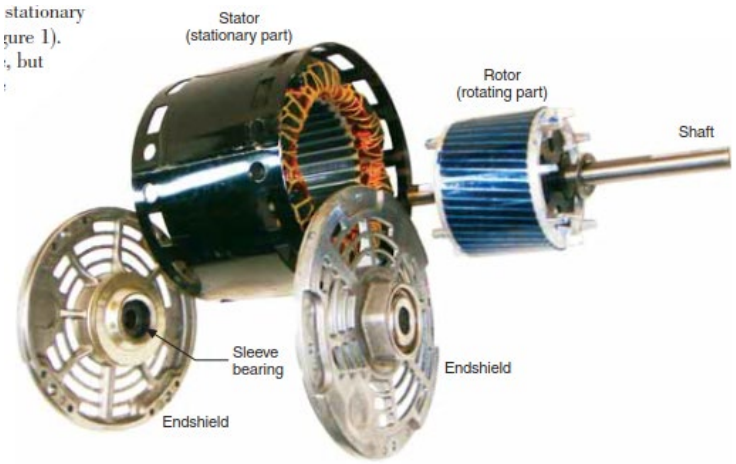


Figure 1. Typical ac induction electric motor

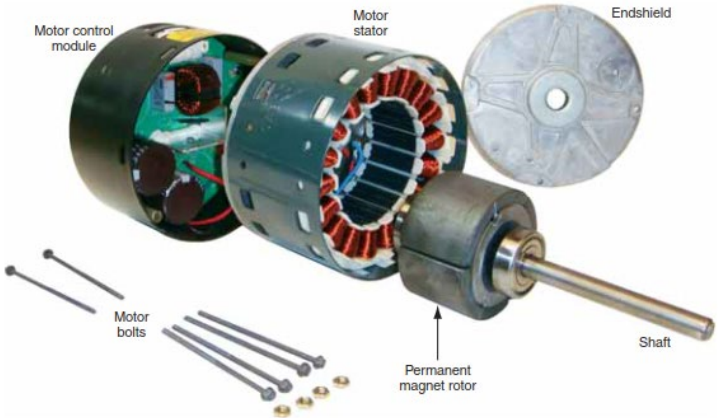


Figure 3. ECM exploded view

High Efficiency Evaporator Fan Motor (New & Retrofit)

- Rebate Requirements:
  - Applies to ECM Motors
  - Other motor types considered on case-by-case basis
    - Must show similar efficiencies
- Rebate Amounts:
  - New evaporators = $10/motor
  - Retrofit existing evaporators = $40/motor

High Efficiency Evaporator Fan Motor (New & Retrofit)

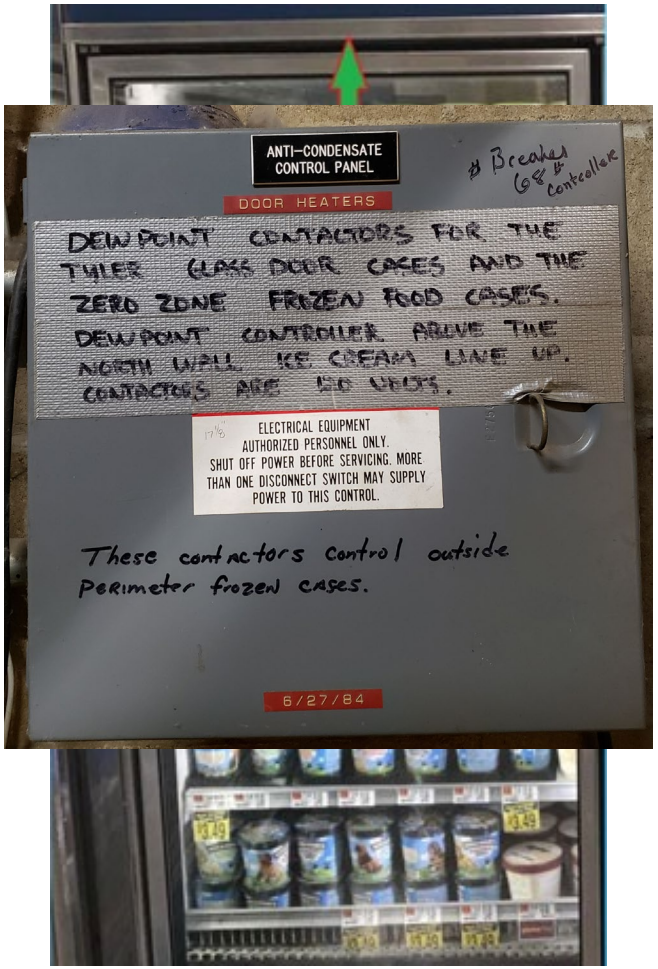
- Benefits:
  - Consume less energy
  - Ability to modulate fan speed (ECM only)
  - Lower maintenance needs
  - Longer life spans
  - Easy to retrofit

Antisweat Heater Control (New & Retrofit)

- Electric heaters heat refrigerated case doors to prevent condensation
  - Warm air enters when door opens
  - Warm air will cool when it touches inside pane of glass door, creating condensation
- Commonly operate continuously
  - Generally only needed 15-20% of the time

Antisweat Heater Control (New & Retrofit)

- How to identify:
  - Open/close door to see if condensation is produced
  - Feel the three locations on case doors for a warmer temperature
  - Look for an antisweat heater controller



Antisweat Heater Control (New & Retrofit)

- Rebate Requirements:
  - Level 1: Retrofit only
    - *Controller measures space humidity or dew point near cases*
    - Turns off or reduces power use during low humidity periods
    - Existing heater input is 10 watts/foot of display case
    - Rebate = $20 per linear feet of display case

Antisweat Heater Control (New & Retrofit)

- Rebate Requirements:
  - Level 2:
    - New and retrofit
    - *Controller measures moisture on glass doors*
    - Turns off or reduces power use during low humidity periods
    - Existing heater input is 10 watts/foot of display case
    - Rebate = $40 per linear feet of display case

Antisweat Heater Control (New & Retrofit)

- Benefits:
  - Less energy used by heaters
  - Less heat emitted in case
    - Refrigeration system consumes less energy

Outdoor Air Cooling (New & Retrofit)

- Walk-in coolers only
- Measures and compares indoor/outdoor temps.
  - If outdoor temp is far enough below indoor temp. (≈15°F)
    - Compressor is turned off
    - Outside air is brought in
- Provides “free” cooling

Outdoor Air Cooling (New & Retrofit)

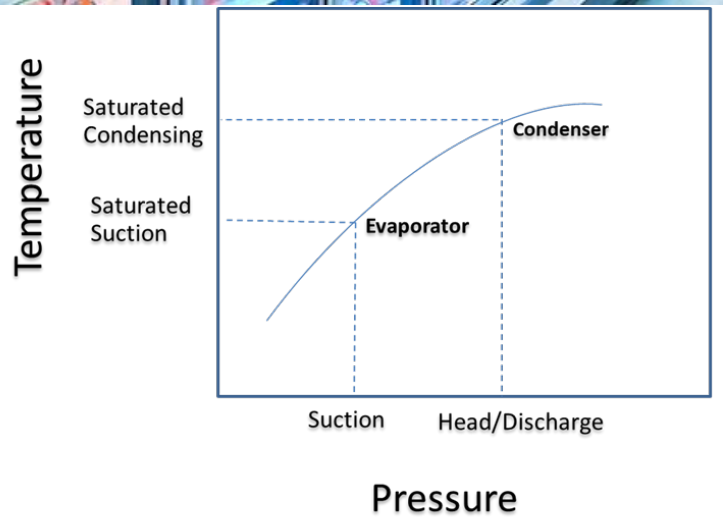
- Rebate Requirement:
  - Must measure indoor and outdoor temperatures
  - Outdoor temperature well below walk-in cooler temp (≈15°F)
  - Compressor must be deactivated during outdoor air cooling
- Rebate = $2 per cfm of airflow

Outdoor Air Cooling (New & Retrofit)

- Benefits:
  - “Free” cooling
  - Compressor runtime is reduced
    - Less energy consumed

High Evaporator Temperature Cases (New & Retrofit)

- Medium temperature cases only
- Refrigerated cases designed for higher saturated suction temperatures
- Compressors starting point on uphill climb increases
- May require separate compressor group



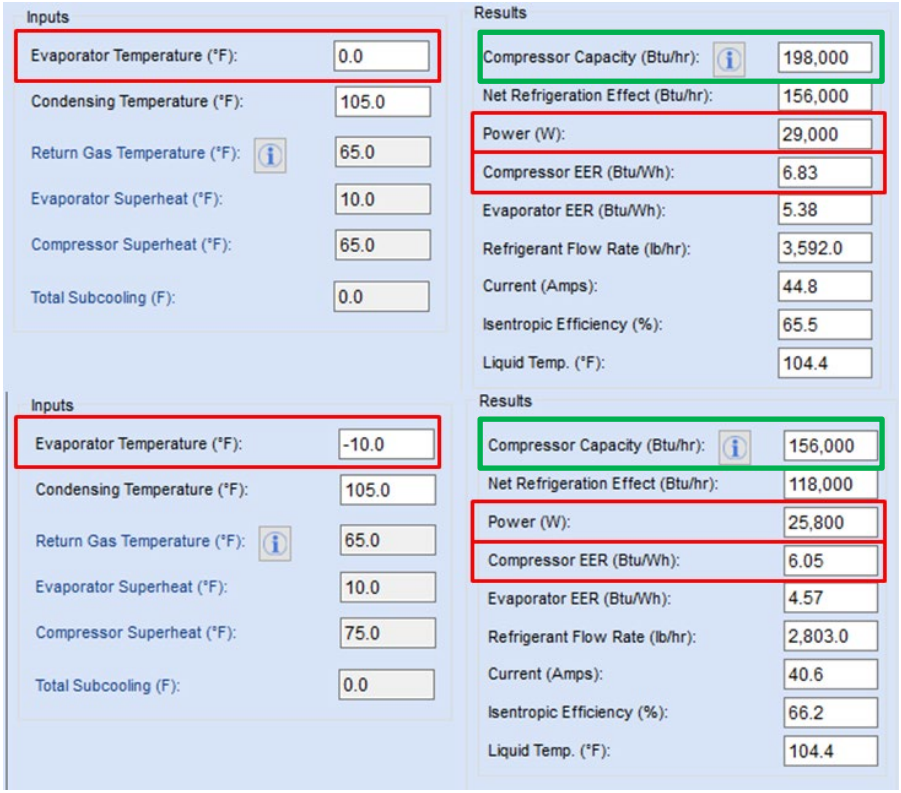
High Evaporator Temperature Cases (New & Retrofit)

- Rebate Requirements:
  - Compressors must operate at a certain min. saturated suction temps.
  - Multiple compressor capacity steps
    - Required for more than two high temp evaporators
- Rebate = $20 per linear foot of case

Application	Minimum-rated evaporator temperature	Minimum-suction saturated suction temperature
Produce and dairy	28° F.	26° F.
Meat	24° F.	22° F.

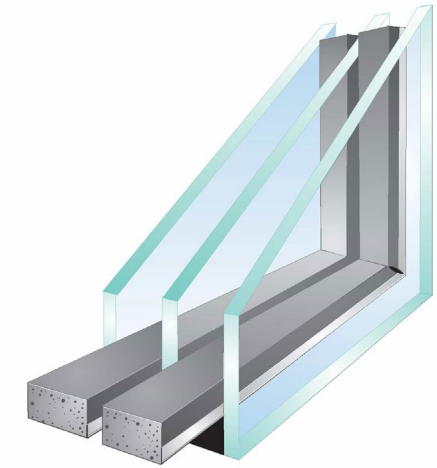
High Evaporator Temperature Cases (New & Retrofit)

- Benefits:
  - Increases compressor efficiency
    - Consumes less energy annually
    - Reduction in runtime hours
  - Compressor refrigeration capacity increases



High Efficiency Glass Doors (New & Retrofit)

- Older case glass doors may be single pane
  - Heat gain into case can be high
- Types of efficient glass doors
  - Two pane w/ low-e coating
    - Similar affect as low-e ceilings
  - Three pane (option of low-e coating)



High Efficiency Glass Doors (New & Retrofit)

- Rebate Requirements:
  - Must be two pane with low-e coating or three pane glass
  - Medium Temperature Cases/Walk-ins
    - No antisweat heaters on door extrusion and glass
    - External frame antisweat heater input power less than 18 watts per linear foot of door front
  - Low Temperature Cases
    - Total antisweat heater input power less or equal to 40 watts per linear foot of door front
- Rebate = $40 per linear foot of case

High Efficiency Glass Doors (New & Retrofit)

- Benefits:
  - Less heat radiates into case from the store
  - Reduces refrigeration load
    - Refrigeration system consumes less energy

LED Lighting (New & Retrofit)

- Fluorescent bulbs commonly used in older refrigerated cases
  - High input watts
  - More heat emitted in cases
  - Poor quality of light
- LED lights are an easy retrofit
  - Light Emitting Diode
  - Individual diodes emit light
  - Lower input watts

LED Lighting (New & Retrofit)

- Rebate Requirements:
  - All lights must be LED
  - Can be implemented for new or existing cases
  - Applies to low and medium temperature cases
- Rebate = $100 per door

LED Lighting (New & Retrofit)

- Benefits:
  - Reduction in lighting energy consumption
    - Additional energy savings with Grocery Store Case Lighting Control measure
  - Less heat emitted in case
    - Refrigeration system uses less energy
  - Quality of light improves
  - Longer lamp life

OTP Rebates new for 2024

Case Lighting Controls

- Retrofit Only
- Occupancy sensor control of lights within glass door cases are eligible for this rebate in all stores. Scheduled time-controls are only eligible where the store's operating hours and overnight stocking practices allow the lights to be scheduled off for an average of at least 7 hours every night.
- Occupancy sensors can be integrated into the cases or separate, but each occupancy sensor must serve a control zone that is no larger than a single aisle and the sensor shall not sense movement beyond the end of an aisle.
- Occupancy sensor time-delays for turning off or reducing power by at least 50% shall be no more than 5 minutes.

Door addition to open Cases

- Coolers and Freezers
  - Retrofit only

- This rebate is intended for the addition of glass doors to existing cases, or the replacement of existing open cases with glass door cases. The rebate amount will be limited to the linear feet of existing case that is either retrofit with glass doors or replaced. New cooler doors must not have an antisweat heat in the glass to be eligible for this rebate.

Night Shades

- Coolers and freezers
  - Retrofit only

- Night shades to provide a thermal barrier between the cooled portion of an open case and the ambient air must be in the form of permanently installed, retractable night covers. Both manually operated and motorized shades are eligible.

Replace Island Case

- Only the removal of island cases and the installation of glass-door multideck cases for the same type of products are eligible. The rebate amount will be limited by the lesser of the length of new glass-door cases for the same products and the display length of the island cases that are being replaced.
- For island cases with an open product area less than 36 inches wide, the islands' linear feet of display length shall be measured at the length from one of the case to the other. For island cases 36 inches or wider, the display length shall be calculated as the length of the perimeter of the case minus 6 feet (based on 1.5 feet for each corner).
- In order to be eligible, replacement cooler cases must have no antisweat heat in the door glass.

TXV to EEV

- This rebate is for the use of electronic expansion valves (EEVs) in lieu of thermostatic expansion valves (TXVs) in rack refrigeration systems. In order to qualify for rebates, it must be reasonably expected that the use of EEVs will allow for at least a 1°F increase in a suction group's saturated suction temperature (SST) and/or at least a 5°F reduction in the minimum saturated condensing temperature (SCT) when compared to the same system with TXVs.
- For new racks, adequate documentation could be in the form of a manufacturer or designer showing alternate designs with the different design saturated temperatures, or a documented statement from the rack manufacturer or professional designer clearly stating what the design values are for SST and minimum SCT for each suction group with EEVs, and what each of these would have been with TXVs.
- In retrofit situations, a similar indication from the rack manufacturer or a designer should be provided prior to proceeding with the work, and pre-post observations of these control setpoints must be documented.

Adiabetic Condenser

- This rebate is intended for the installation of new adiabatically pre-cooled condensers and gas coolers. The retrofit of existing air-cooled condensers (or gas coolers) with an add-on product that provides similar pre-cooling will be considered on a case-by-case basis, or as a custom rebate. engineered pre-cooling. The adiabatic condenser (or gas cooler) must be controlled with the water for pre-cooling active down to an outdoor temperature of 65°F or lower.

Low Speed Condenser Fans

- This rebate is intended for the selection of new condensers (and gas coolers) with axial (propeller) fans that have a maximum running speed of ≤ 900 rpm. Condensers with variable speed controlled ECM motors ARE NOT ELIGIBLE when they are designed to run at higher speeds under high loads or ambient conditions and only reduce the speed below this maximum for a portion of their annual running time.

Evaporator fan motor measures

- Permanent magnet fan motors (new & retrofit)
- Permanent magnet synchronous motors are eligible for this rebate. Other motor technologies will be considered on an individual basis if equivalent efficiency levels can be demonstrated.
- Motors that receive rebates through other Otter Tail Power programs are not eligible for an additional motor rebate through this program.

Digital Capacity Modulation

- Digital capacity modulation (new and retrofit)
- This rebate is meant to promote the use of fine-step capacity control on one compressor in each suction group in a way that reduces fluctuations in suction pressure and provides a higher average suction pressure. The fine-step capacity modulation of one compressor can be achieved by either a variable speed control of the compressor, at least two stages of cylinder unloading, or digital capacity contro

Digital Capacity Modulation Cont.

- Prior to installation, the compressor control algorithm shall be detailed in a way that clearly shows that a suction group's time-averaged suction pressure is maximized through a reduction in pressure swings and/or an increase in the suction pressure setpoint. These descriptions must be attached to the rebate application form and should include the best available information on pre-existing (or baseline design compressor control strategy for new rack systems) and new control settings and deadbands.
- Rebates will be based on the total horsepower of suction groups at least one compressor having fine compressor capacity modulation with a control strategy that takes advantage of the potential to increase time-averaged suction pressure.

Strip Curtains

- Coolers and Freezers
  - New or Retrofit

- This rebate is for the installation of strip curtains in the doorways of walk-in coolers and freezers to reduce air flow and heat gain when the main door is open. Strip curtains shall be at 0.06 inches thick and strip curtains installed in freezer doorways must be stated by the manufacturer as being approved for use in freezer applications.

OTP Refrigeration Optimization

- What is the end goal of optimization
  1. Keep equipment dependable and continously operating
  2. Identify low or no cost setpoint solutions to save business owners on their energy and operating costs
     - A typical large grocery store could save 271,000 kWh per year simply by optimizing setpoints on existing controls
     - This correlates to nearly $28,000 yearly, a substantial savings for stores with low margins and little room for error

OTP Refrigeration Optimization

- How are recommendations determined?
  1. Customer provides basic information about their system and allows CEE to access their electric usage data
  2. A joint onsite refrigeration assesment is completed with the business, CEE, and contractor
  3. A Report is provided to the customer with recommended actions, which will include cost savings, applicable rebates, energy demand savings, and expected payback

OTP Refrigeration Optimization

- What happens next?
  1. Following the report presentation, the business owner and contractor will work to implement setpoint changes
  2. Business owner will provide OTP with proof of paid invoices verifying completion of recommended changes.

OTP Refrigeration Optimization

- Eligible customers can be reimbursed up to $10,000 toward the cost of a refrigeration optimization study, and up to $2500.00 for contractor implementation costs, in addition to any applicable equipment rebates. These reimbursable costs can include...
  - Contractor time to attend the visit
  - Contractor time for implementation of low-cost control recommendations
  - Equipment upgrades required for remote data access

*To qualify for reimbursement, all measures with a combined payback of less than 2 years must be implemented

Preventative Maintenance

- Consists of regular, routine maintenance checks
- Helps prevent unanticipated issues
- Catches equipment problems before they fail

Preventative Maintenance

- Minimum items to be checked:
  - Walk-in freezers/coolers
    - Clean condenser/evaporator coils
    - Check refrigerant levels
    - Check fan operation
    - Verify temperature setpoints
  - Air Handler and Heat Reclaim Coil (if applicable)
    - Clean evaporator/heat coil, return air grille, condensate drain pan
    - Check fan belts and bearing
    - Notify owner of conditions
  - Frozen treat machines
    - Clean fan, evaporator/condenser coils, screen and filter

Preventative Maintenance

- Minimum items to be checked:
  - Miscellaneous refrigerated cases, stand-alone cooler/freezers, & specialty coolers
    - Check refrigerant levels
    - Clean coils and fan
    - Flush condensate pump
  - Ice merchandisers (indoor and outdoor)
    - Verify set point (0°F)
    - Check refrigerant level
    - Clean condenser
  - Thermometers, door heaters and controls
    - Verify proper operation

Preventative Maintenance

- Rebate based on refrigeration system compressor size
- Preventative maintenance and application must be completed by December 31st to qualify for current year rebate

Preventative Maintenance Reimbursement Schedule	
Total Compressor HP at Site	**Max Contractor Reimbursement**
1 to 30	$ 325.00
31 to 100	$ 500.00
101 to 200	$ 650.00
201 and larger	Call for approval

Preventative Maintenance

Saves Money

- Prevents costly repairs
- Saves in utility costs
- Reduces operating costs

Keeps Employees Happy, Comfortable

- Supports healthy, productive and safe environments
- Helps avoid costly work disruptions
- Addresses issues before they become urgent

Saves Energy, Improves Performance

- Maximizes efficiency
- Improves system reliability
- Reduces energy use and expenses

More Maintenance Less Repairs

- Increases equipment lifespan
- Reduces risk of c atastrophic failure
- Reduces need for costly emergency repairs

Questions?