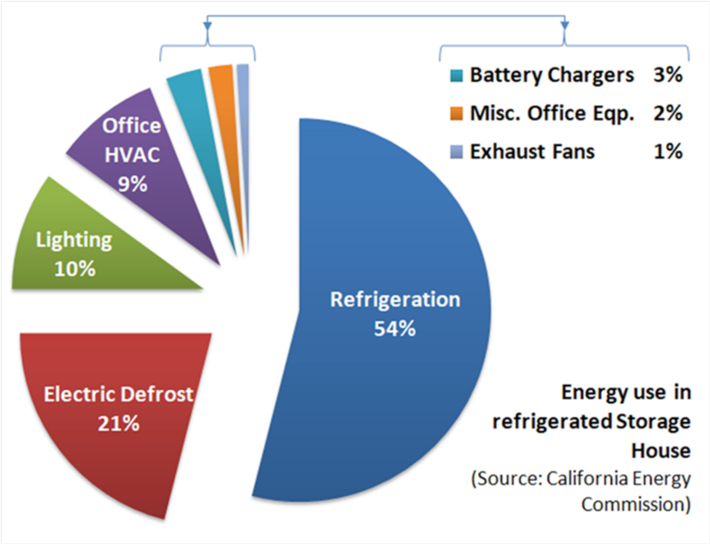
EMIS Archetype for a Vapor Cycle Refrigerated System

Vapor-cycle refrigeration systems are used for various types of installations from refrigerated warehouses and cold storages to walk-in freezers and retail space coolers.

There are multiple ways to reduce its operating costs but, in order to achieve those savings, one needs to continuously monitor the refrigerated system performance via a number of meters, sensors and gauges measuring energy, pressures, temperatures on the refrigerant side of the system as well as temperatures and humidity inside the refrigerated space. Depending on the condenser type selected (i.e. air, water or evaporative cooling), extra temperature monitoring should be installed to ensure optimal performance.



1. What to Monitor and Where to Locate Meters, Sensors and Gauges

(See Refrigerated Warehouse diagram on next page for typical locations of meters, sensors and gauges)

Refrigerant Side

- PM Power (energy) meters for each compressor and hours run meters.
- P Pressure sensors on condenser side and suction sides
- T Temperature sensors on condenser and suction sides

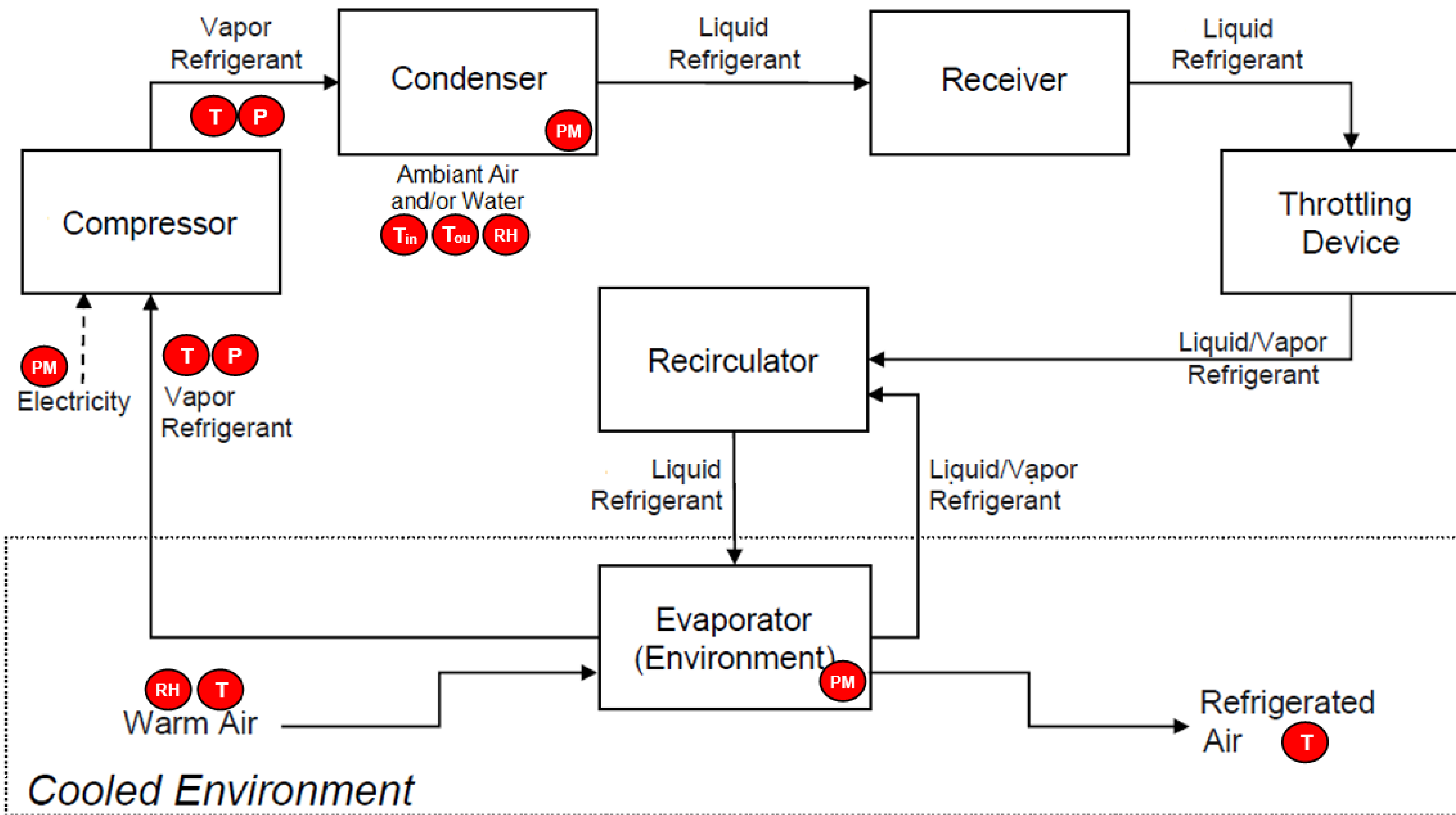
Refrigerated Space Side

- Refrigerated volume (for heat loss rate)
- Mass of goods being refrigerated
- T Initial Temperature of goods being refrigerated
- T Final Temperature of refrigerated products
- RH Relative humidity
- PM Evaporator Fan Power and internal load (i.e. lighting)

Condenser side

- T Ambient air temperature
- RH Relative humidity or wet bulb temperature of ambient air
- PM Condensing system power (air, water or evaporative cooling systems)

2. Typical Vapor Cycle Refrigeration System (single stage)



3. Energy Performance Models & Time Series Trending

Model Description	Form of Model	Enabled Operational Opportunities
Compressor and Fan Energy vs mass of food to be refrigerated and outside air temperature.	Power = function (tons and initial temperature of products entering refrigerated space, outside air temperature, outside air humidity) • Multi-variable, linear regression model with non-zero intercept	• Efficiency of refrigeration system as a KPI

Parameter to Trend	Description
Power (and Energy)	Continuously trending energy and power allows to quickly identify any issues with the refrigeration system.
Temperature of refrigerated space	Going below recommended guidelines for temperature range for a given type of food could result in higher energy cost than required. On the other side, not being able to maintain a minimum temperature could indicate an issue which that might need further investigation (like refrigerant leaks).
Refrigeration system "lift" : (difference between suction pressure and discharge pressure) Discharge (or condenser) Pressure/temperature Suction (or evaporator) Pressure/ temperature	Reducing lift by raising suction or lowering discharge pressure increases compressor efficiency. Reducing condenser pressure by 10psi can decrease refrigeration system energy use per ton of refrigeration (kW/ton) by about 6%. A raise in suction temperature of one degree Fahrenheit increases the compressor efficiency of an industrial ammonia system by about 2% It is estimated that energy savings of about 8% can be realized with two-stage systems when the suction temperature (and therefore pressure) is raised from -30°F to -20°F. • Suction pressure should be held where compressor power and evaporator fan power are at a "combined minimum." • When no fan savings are possible, set suction pressure as high as possible. A small increase in suction pressure will often let the operator shut off a compressor. This strategy should be pursued aggressively—particularly for systems with screw compressors.
Humidity	Infiltration of moisture into a frozen food warehouse will lead to deposits on the evaporator coils in the form of frost, decreasing the system efficiency. Periodically, the coils must be defrosted to remove the accumulated moisture.
Defrost frequency and duration	Common design practice for defrost control is to utilize a time clock for scheduling defrost times and terminating the defrost based on time or temperature. High performance defrost controls utilize an accumulative run time or on-demand defrost. Smart defrost controls: savings of 10% of compressor energy use.

More Information

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