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TIPS & TOOLS:

Lowering Condensing Pressure – Why Do It?

The selection of a lower condensing head pressure is one of the best ways to reduce energy costs to save energy in an ammonia refrigeration system. The larger condenser saves money all year round, and offers the user a longer useful lifetime as well. This engineering report covers condenser sizing factors, and potential energy savings from employing a larger evaporative condenser.

Sizing Condensers: There are three factors influencing the sizing of a condenser:

1) The total heat rejection required – the capacity of the system compressors.
2) The local climate conditions – the design wet bulb temperature
3) The design condensing temperature

The first two factors are a given and cannot be changed. The third is a design decision between the owner and designer and the subject of this article.

Total Heat Rejection: Total heat rejection is based on the total compressor capacity of the plant including a factor for oil cooling and excluding any back-up machines. The equation is: (BHP x 2545) + (TR x 12000) = Total Heat Rejection, BTU/hr

Wet Bulb: Evaporative condensers work by evaporating water over the condenser's tube bundle – cooling the refrigerant gas inside. The temperature at which the water will evaporate on any given day is called the wet bulb temperature. The wet bulb temperature is a measure of the humidity in the air. If the humidity is high, the wet bulb temperature is high. The dry bulb temperature, which is the temperature measured by a thermometer, has significantly less effect on condenser performance. Refrigeration system designers size condensers using the ASHRAE 1% wet bulb temperature for a given location. In other words, 99% of the time the wet bulb temperature will be below that value. Typical wet bulb values for the Northern United States are between 72ºF and 80ºF.

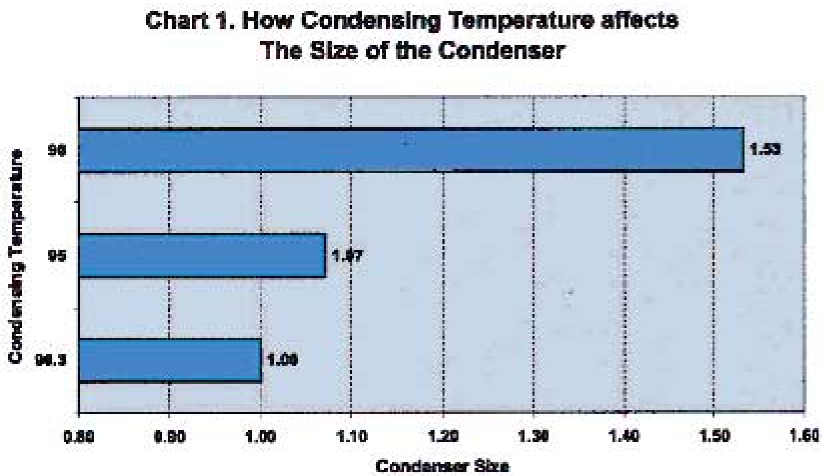
Design Condensing Temperature: This is a key economic design decision. Lowering the design condensing temperature lowers the energy consumption by the compressors. However, lowering the design condensing temperature also increases the size and cost of the condenser, raising installation costs. Thus, the decision is balance between initial construction cost and operating costs.

There are 3 design condensing temperatures typically used for ammonia refrigeration systems.

96.3ºF	185 psig	(older standard design)
95ºF	180.7 psig	(newer standard design)
90ºF	165.9 psig	(enhanced design)

Using the older standard of 96.3ºF as a base, lowering the design condensing temperature has the following effect on size, or base rating, of the condenser.

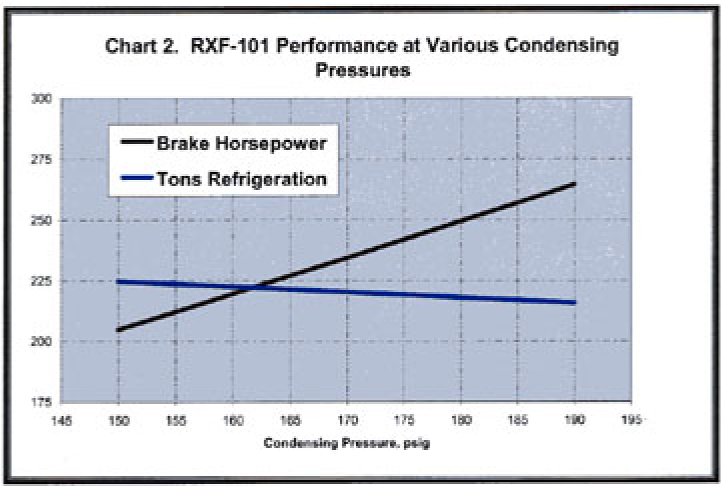
Chart 1. How Condensing Temperature affects the Size of the Condenser



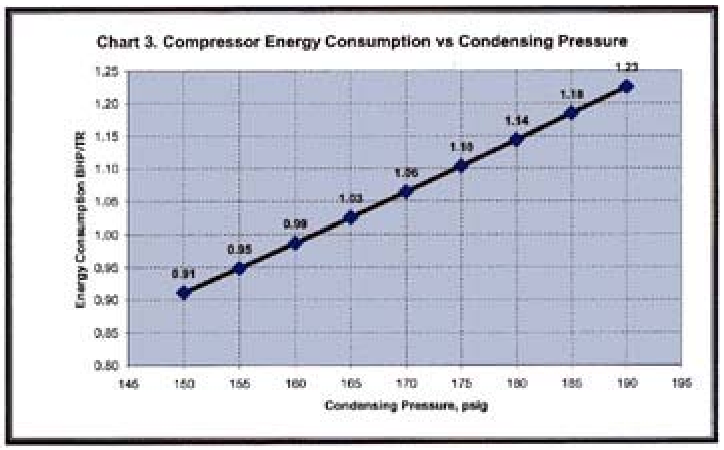
Thus, a 90ºF condenser is over 50% larger than a 96.3ºF condenser. Condenser size, or capacity, is mostly achieved through a larger coil bundle – more surface area of pipes. In general, a 90ºF condenser has 50% more tube area than a 96.3ºF condenser.

How does a larger condenser affect energy consumption?

Consider a typical high stage compressor, operating at 20ºF suction and discharging at various pressures. As the discharge pressure gets lower, the capacity of the compressor increases, and the BHP/TR (energy input per ton refrigeration) goes down. Therefore, in effect, it does more for less. The following two graphs show the relationship between condensing pressure and compressor performance/energy consumption for various head pressures.



[This in more clearly shown in the BHP/TR performance chart, Chart 3.]



Peak Condensing Period Savings: Clearly, the lower the condensing pressure, the lower the energy consumption of the compressor. The difference between 95ºF (180.7 psig) and 90ºF (165.9 psig) condensing is approximately 15% lower energy consumption. Thus, at peak condensing conditions, the larger condenser saves 15% of the compressor energy costs. However, in Northern climates, and only during daytime hours. Thus the non-peak performance is also a significant factor.

Spring and Fall Savings: During the spring and fall of the year, the refrigeration system operates at less than peak design conditions. Note that Chart 3 shows a relatively linear relationship between condensing pressure and energy consumption. The larger condenser will achieve consistently lower head pressures throughout this period, due to its greater surface area. The 90ºF condenser will typically have 15 psig lower condensing pressures than the 95ºF condenser, maintaining 12% lower compressor energy cost during this time period as well.

Winter Savings: In winter, the energy savings is reduced, but the larger condenser will still require less fan and pump horsepower than the smaller alternative.

Other Considerations: Scaling of the condenser tubes from hard water is a major factor affecting a condensers useful life. Even the best warm water treatment will not prevent scale from eventually building up, but it will slow it down so that it will take many years before it becomes a problem. Condenser manufacturers report that even a very thin layer of scale on tubes has a significant effect on condenser performance.

For example, with a fouling factor of 0.003 (0.036-in scale thickness) the additional energy cost per year for a 500 ton chiller is $25,300. The larger sized condenser has a built in safety factor of approximately 50%, allowing it to operate satisfactorily for years even with some tube scaling, whereas the marginally sized condenser will lead to high head pressure problems much sooner. Thus, the larger condenser will have a significantly longer useful life.

Conclusions: The larger condenser is a good investment. It allows the compressors to work less and thus lowering their energy consumption. It utilizes fewer fans and pumps during the cooler seasons of the year, and lasts longer than the marginally sized alternative. In most cases, the larger condenser will pay for itself in just a few years while benefiting the system owner for many years.