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PRINCIPLES OF REFRIGERATION

SUPERHEAT

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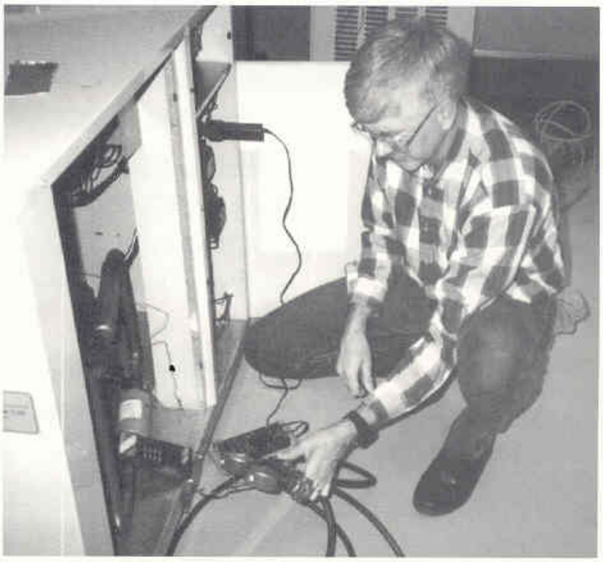
Superheat continues to be an important topic in the refrigeration industry. This article discusses superheat from the service man's perspective.

Before discussing superheat, you need to know what device is used in commercial refrigeration to control superheat: the Thermostatic Expansion Valve. This valve regulates the rate of refrigerant liquid flow into the evaporator in the exact proportion to the rate of evaporation of the refrigerant liquid in the evaporator.

The amount of refrigerant gas leaving the evaporator can be regulated since the valve responds to: (1) the temperature of the refrigerant gas leaving the evaporator; and (2) the evaporator pressure. By controlling the flow of refrigerant into the evaporator, the heart of the refrigeration system can be protected by preventing the flow of liquid refrigerant to the compressor. The three forces governing the expansion valve's operation are: (1) the remote bulb pressure; (2) the evaporator pressure; and (3) the superheat spring pressure.

The superheat spring is the adjustable part of the expansion valve. It allows the expansion valve to be adjusted for a particular evaporator and room use. The location of the remote bulb is also very important to operating the expansion valve properly. The remote bulb should be attached to the suction line as close to the evaporator as possible. The remote bulb should be on a horizontal line upstream from the external equalizer connection at the 10 or 2 o'clock position and before the suction line trap. (The actual position of the remote bulb can vary from this position, but should never be located at the very bottom or top of the pipe.) The bulb should be insulated along with the suction line at the point of contact using a good moisture resistant insulation. If the bulb is not insulated, the ambient temperature will influence the operation.



Checking system superheat at the condensing unit.

WHAT IS SUPERHEAT?

After the liquid refrigerant has changed to a vapor, any additional heat added to the vapor raises its temperature as long as the pressure to which it is exposed remains constant. "Superheated vapor" describes a gas with a temperature higher than its saturation temperature corresponding to its pressure.

Example: A refrigeration evaporator is operating with Refrigerant 22 at 69 psig. The Refrigerant 22 saturation temperature is 40°F according to the pressure/temperature charts. As long as any liquid Refrigerant 22 exists at this pressure, the refrigerant temperature will remain 40°F as it boils off in the evaporator. As the refrigerant moves along in the coil, the liquid boils off into a vapor, causing the amount of liquid present to decrease. When all of the liquid refrigerant has evaporated, it has absorbed sufficient heat from

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the surrounding atmosphere to change from a liquid to a vapor. As the refrigerant vapor completes its journey through the evaporator, it has continued to absorb heat from the surrounding atmosphere. This amount of heat is referred to as superheat and can be calculated by measuring the temperature of the vapor. If the temperature of the vapor exiting the evaporator coil is 50°F and the pressure has remained a constant, then the amount of superheat is 10°F.

Pressure = 69 psig

Saturated Temperature = 40°F

Actual Vapor Temperature = 50°F

To find the superheat, always subtract the Saturated Temperature from the Actual Temperature.
50°F - 40°F = 10°F

SUPERHEAT ADJUSTMENT

Rely on the thermostatic expansion valve to control the amount of superheat of the suction gas exiting the evaporator coil. You can accurately measure the superheat of the evaporator only after the room in which it is operating is near the design temperature.

Check the evaporator superheat after a defrost period when the evaporator fin surface is relatively clean and free of excess frost and after the system has settled down. After each adjustment of the expansion valve, you should wait at least 15 minutes before taking the superheat reading or making further valve adjustments.

The method of measuring superheat that Heatcraft recommends is the pressure / temperature method read at the evaporator outlet. Other methods can yield an incorrect superheat that can be misleading when used to analyze system performance.

When measuring superheat, install a calibrated pressure gauge in a gauge connection at the evaporator outlet. If there is no gauge connection, you can use a branch tee with a service valve installed in the expansion valve external line just as effectively. Secure the thermometer or temperature probe to the suction line at the point of the remote bulb location and insulate it against ambient air. The thermometer will give an average reading of the suction line and the ambient if not insulated. Assuming an accurate gauge and temperature meter, this will provide sufficiently accurate superheat readings for all practical purposes. This is the preferred method of obtaining the evaporator superheat.

Sometimes other methods of measuring superheat are used. The "two temperature method" uses the difference in temperature between the evaporator inlet and outlet as the superheat. This method can produce a false reading because the pressure drop of the evaporator has not been accounted for. Where the pressure drop between the evaporator inlet and outlet is 1 psig or less, the two temperature method will yield fairly accurate results. However, evaporator pressure drop is usually an unknown and will vary with the load. For this reason, the two temperature method cannot be relied on for absolute superheat readings.

Another method commonly used to check superheat involves taking the temperature at the evaporator outlet and using the suction pressure measured at compressor as the evaporator saturation pressure. But if the pressure drop between the compressor

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and the evaporator outlet is not taken into account · if it is in error because of an excessive pressure drop, the superheat reading will be in error.

On close-coupled installations, the pressure drop and resulting error are usually small. But on large systems or systems with long runs of suction line, inaccurate readings will usually result. Since estimates of suction line pressure drop are usually not accurate enough to measure the superheat accurately, you cannot rely on this method for absolute values. (The error in this instance will always be positive and the resulting superheat will be higher than the actual value.)

Superheat and the Compressor

Superheat's primary function is to protect the compressor; improving the efficiency of the evaporator is secondary.

Most compressor manufacturers have a minimum recommendation for superheat at the compressor. Superheat is measured at the compressor the same way it's measured at the evaporator. For most applications, measure the temperature of the suction line 8" to 12" from the suction service valve and near the bottom of the line. Make certain to securely fasten and insulate the temperature probe to the suction line. Measure the suction pressure at the suction service valve and convert it to its corresponding saturated suction temperature.

A 30°F superheat is desired to ensure the return of dry gas to the compressor suction chamber. Lower superheat can result in liquid refrigerant flooding back to the compressor during variations in the evaporator feed, with possible compressor damage as a result. Excessively wet refrigerant vapor continually returning to the compressor can reduce the lubricating qualities of the oil which can result in compressor failure. Failures resulting from this condition are generally not readily associated with low superheat. Depending on the problem's severity, the system might appear to operate normally for months or even years, until the compressor fails for no obvious reason.

The actual superheat measured at the compressor can vary due to many factors: the size and type of expansion valve used; adjustment of the expansion valve; placement of the expansion valve thermal bulb; the length of refrigerant piping; ambient air around the refrigerant piping; amount and type of insulation on the suction line; degradation of the piping insulation; wet piping insulation; discharge pressure; liquid refrigerant temperatures; box temperatures; product loading; and accessories in the suction line such as suction filters, accumulators, EPR Valves, CPR Valves, etc.

Superheat should be adjusted at the evaporator expansion valve.

On close-coupled systems, expect minimal heat gain in the suction line and lower superheat at the compressor. Superheat in the range of 20°F might be normal. On systems with long suction lines, expect more heat gain, resulting in higher superheat at the compressor. Superheat ranging from 30° to 70°F might be normal. As long as the suction gas returning to the compressor is within the manufacturers recommended guidelines in keeping the compressor cool, there should not be a problem.

An example of higher compressor superheat and normal system operation is: Refrigerant 502 low temperature system; Suction pressure is 6 psig which = -36° saturated suction temperature. The actual suction line temperature = 24°F. Remembering the formula, the actual suction temperature less the saturated suction temperature equals the superheat — 24 - (-36) = 60°F superheat.

The 24°F suction gas temperature is well below the manufacturers recommended temperature in assuring cool gas return, and the superheat is well above the minimum recommended 30°F. This compressor is operating properly under the given conditions.

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Some ice may accumulate on the exposed suction line at the compressor service valve, but this means only that the suction line is below the freezing point and the moisture in the atmosphere has condensed and frozen to this object. Ice accumulation on the suction line is not an abnormal situation for commercial refrigeration applications and should not be a cause for alarm. In these situations, remember, "Check the superheat."

Temperatures and pressure alone may not always give a true picture of the actual liquid refrigerant control in a system. A little-known factor which might affect superheat measurements is excessive oil circulating in the system.

Excessive oil circulation increases the evaporating temperature of the refrigerant. The response of the expansion valve is based on the saturation pressure and temperature of pure refrigerant. In an operating system, the changed pressure-temperature characteristics of the oil-rich refrigerant will give the expansion valve a false reading of the actual superheat and can result in a somewhat lower actual superheat than apparently exists. As a result, excessive liquid refrigerant can return to the compressor.

The solution for this condition is to minimize oil circulation. Improper refrigerant piping can influence oil circulation in a system. Excessive oil in the evaporator can result from an excessive oil charge in the system or other factors which can cause excessive oil circulation. Low velocities in the evaporator create a condition known as "oil logging" which can also result in a false superheat reading.

There are many factors which can influence the total refrigerant system operation. By planning ahead, installing systems according to manufacturers recommendations and following ASHRAE standards and guidelines, many problem situations can be avoided. Knowing the principles of superheat and how to correctly measure and interpret it can help you to diagnose system problems when they arise.

Information Sources: ASHRAE Handbook, 1988 "Equipment"

Copeland Refrigeration Manual, "System Design"

Sporlan Valve Company, "Thermostatic Expansion Valves," Bulletin 10-11

Alco Controls, "Operating Principles and Application of the Thermostatic Expansion Valve"

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