Identifying Refrigeration Problems Using Superheat and Subcooling

Understanding superheat and subcooling, and knowing how to correctly measure them can help you with refrigeration system troubleshooting

By David Gibbs

Often, measuring temperatures or pressures at key points in a refrigeration system can pinpoint trouble spots. Two key temperature measurements are superheat and subcooling. This article provides detailed explanations of each of these temperature parameters, how to accurately measure them and how to use them to quickly diagnose system problems.

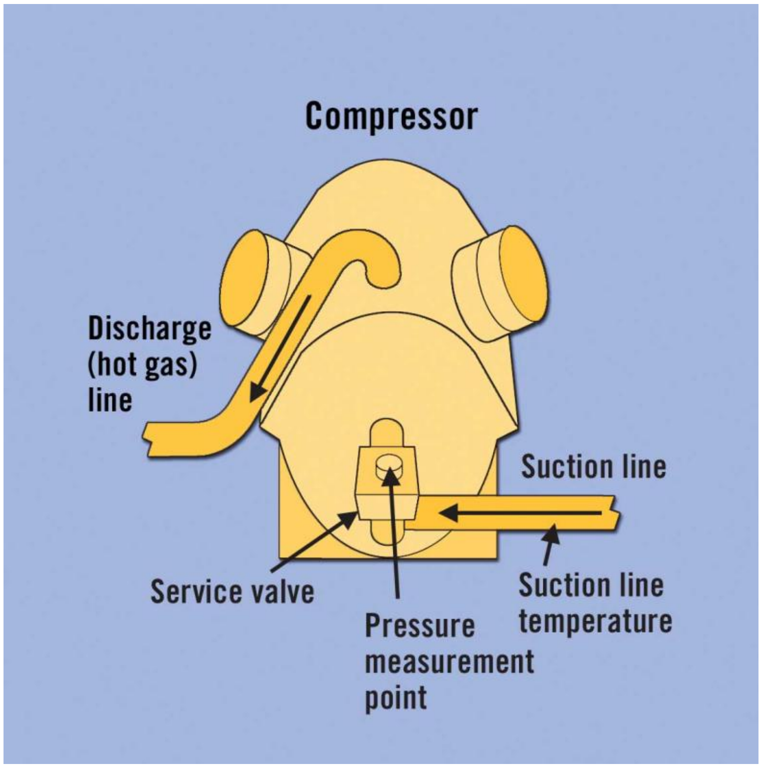

Figure 1.
Finding suction line superheat requires two temperatures

In the system's evaporator, conversion of liquid to vapor involves adding heat to the liquid at its boiling temperature, commonly referred to as the saturation temperature. After the liquid has evaporated, any temperature increase is called superheat.

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Finding suction line superheat requires two temperatures – the evaporator boiling temperature at a given pressure and the temperature of the refrigerant at the outlet of the evaporator on the suction line, commonly referred to as the superheat temperature/pressure method.

Note: Boiling temperature is derived from using a pressure-temperature (PT) chart. On new refrigerant blends with high temperature glide, this is called the dew-point temperature.

The best method to determine superheat is through the use of a pipe clamp temperature probe in conjunction with a pressure/vacuum module. A pipe clamp allows pipe temperature measurements to be made more quickly and accurately than other methods because it clamps directly to the pipe allowing insulation to be added more easily.

When measuring for superheat, allow the system to run long enough for temperatures and pressures to stabilize while verifying normal airflow across the evaporator. Using the pipe clamp, find the suction-line temperature by clamping the probe around a bare, cleaned straight section of the pipe at the outlet of the evaporator.

Pipe temperature can be read at the inlet of the compressor on the suction line if the pipe is less than 15 feet from the evaporator and there is a minimum pressure drop between the two points (see Figure 1). Best results are obtained when the pipe is free of oxides or other foreign material. Next, attach the pressure/vacuum module to the suction-line service valve (or refrigerant service port on your manifold gauge set). Make a note of the pipe temperature and pressure.

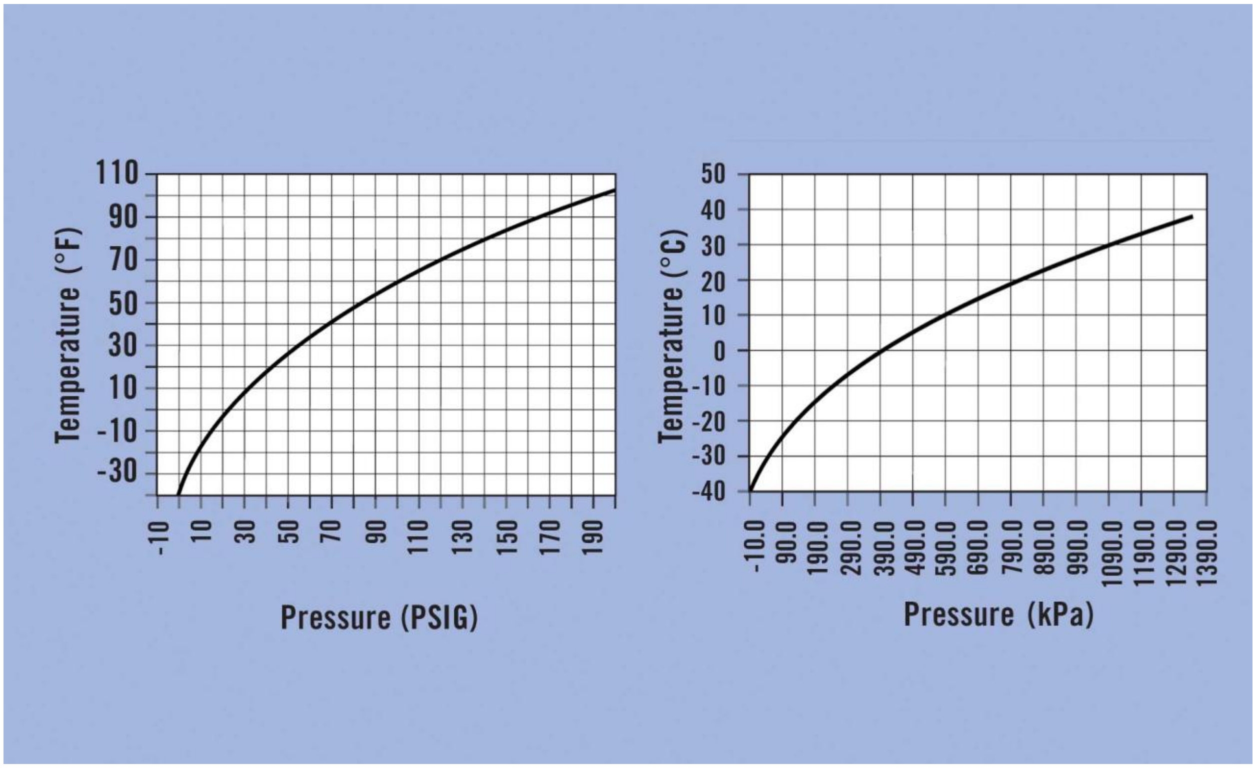

Figure 2.
A pressure-temperature (PT) chart is essential for determining superheat and subcooling temperatures.

This pressure reading will be approximately that of the boiling refrigerant inside the evaporator assuming there are no abnormal restrictions in the suction-line. Using this pressure value, find the evaporator boiling temperature from a PT chart for the refrigerant type being used (see Figure 2).

Subtract the boiling temperature from the suction-line temperature to find the superheat. The suction-line temperature also may be taken by attaching a bead thermocouple to the suction line. Be careful to insulate the thermocouple and use a heat-conducting compound to minimize errors due to heat loss to ambient air.

Subcooling and its measurement

In the refrigeration system's condenser, conversion of vapor to liquid involves removing heat from the refrigerant at its saturation condensing temperature. Any additional temperature decrease is called subcooling.

Finding liquid line subcooling requires two temperatures – the condensing temperature at a given pressure and the temperature of the refrigerant at the outlet of the condenser on the liquid line. The liquid-line temperature involves measuring the surface temperature of the pipe at the outlet of the condenser (see Figure 3).

Note: Condensing temperature is derived using the PT chart. On new refrigerant blends with high temperature glide, this is called the bubble-point temperature.

To measure subcooling with a pipe clamp, allow the system to run long enough for temperatures and pressures to stabilize. Verify normal airflow and then find the liquid-line temperature by clamping the probe around the liquid line. Attach the pressure/vacuum module to a service port on the liquid line or discharge line at the compressor if a liquid line valve is not available.

Keep in mind the condenser and piping will have as much as 15 pounds pressure drop through the circuit to the point of the condenser outlet. This will result in an inaccurate pressure temperature relationship.

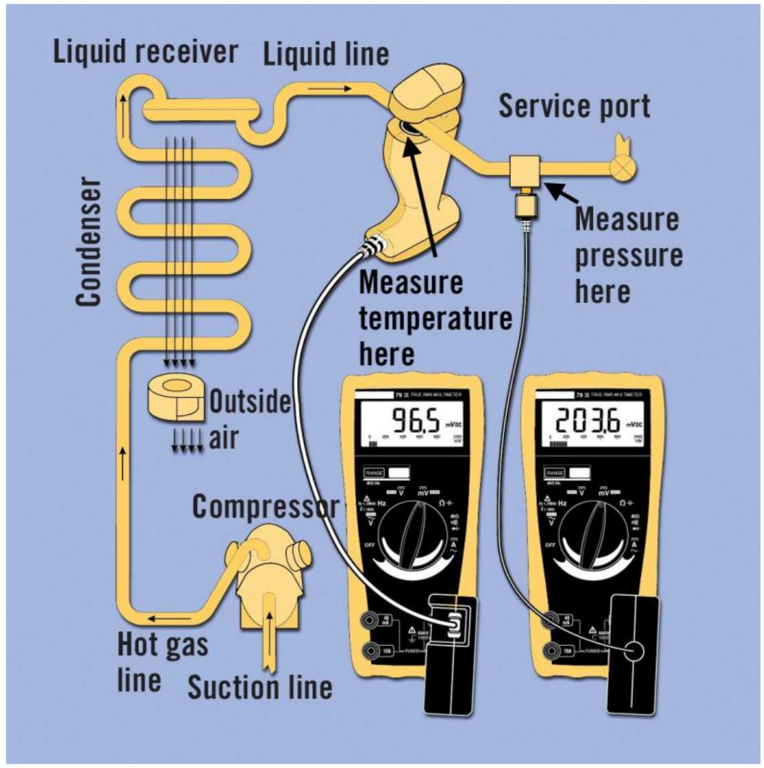

Figure 3.
Finding liquid-line subcooling requires two temperatures the condensing temperature at a given pressure and the temperature of the refrigerant at the outlet of the condenser on the liquid line.

Make a note of the liquid-line temperature and pressure. Convert the liquid-line pressure to temperature using a PT chart for the refrigerant type being used. The difference between the two temperatures is the subcooling value.

Data from superheat and subcooling measurements can be useful for determining various conditions within a system. These include the amount of charge and expansion valve superheat, and efficiency of the condenser, evaporator and compressor.

Before making conclusions from the measured data, check external conditions that influence system performance. In particular, verify proper airflow in cubic feet per minute (CFM) across coil surfaces and line voltage to the compressor motor and associated electrical loads.

Using superheat to troubleshoot

The superheat value can indicate various system problems, including a clogged filter drier, undercharge, overcharge, faulty metering device or improper airflow. Suction line superheat is a good place to start diagnosis because a low reading suggests that liquid refrigerant may be reaching the compressor.

In normal operation, the refrigerant entering the compressor is sufficiently superheated above the evaporator boiling temperature to ensure the compressor draws only vapor and no liquid refrigerant.

A low or zero superheat reading indicates that the refrigerant did not pick up enough heat in the evaporator to completely boil into a vapor. Liquid refrigerant drawn into the compressor typically causes slugging, which can damage the compressor valves and/or mechanical components. Additionally, liquid refrigerant in the compressor, when mixed with oil, reduces lubrication and increases wear, causing premature failure.

On the other hand, if the superheat reading is excessive, it indicates that the refrigerant has picked up more heat than normal or that the evaporator is short of refrigerant. Possibilities include a metering device that is underfeeding, improperly adjusted or simply broken. Additional problems with high superheat could indicate a system undercharge, refrigerant restriction or excessive heat loads upon the evaporator.

Using subcooling to troubleshoot

An improper subcooling value can indicate various system problems, including overcharge, undercharge, liquid-line restriction or insufficient condenser airflow (or water flow when using water-cooled condensers).

For example, insufficient or zero subcooling indicates that the refrigerant did not lose the normal amount of heat in its travel through the condenser. Possible troubles include insufficient airflow over the condenser, the metering device is stuck too far open, it is overfeeding or misadjusted or the system is undercharged.

Excessive subcooling means the refrigerant was cooled more than normal. Possible explanations include an overcharged system, a restriction in the metering device, or a misadjusted (underfeeding) or faulty head-pressure control during low ambient conditions.

Understanding superheat and subcooling, and knowing how to correctly measure these important parameters, can help you quickly and easily troubleshoot a refrigeration system. More information on hvacr troubleshooting is available at http://www.fluke.com/Application_Notes/ElectricalPower/B0302C.pdf.

During the past six years at Fluke and Fluke Networks, David Gibbs has provided expertise as a product specialist and technology trainer within both the Electrical Products and the Media Test Products teams.