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Proper Use Of Superheat Measurements

By Adolfo Wurts

New Instrumentation Assures Accuracy, Saves Energy, And Prevents System Damage.

With increasing energy costs and growing demands for more efficient cooling systems, the need for accurate superheat measurements has become more important. Unfortunately, some technicians have either forgotten what they were taught about superheat in school or think it's too much trouble to perform. They learn the procedure early in school and practice it there, but they find it more difficult in the field, largely because of forgotten techniques or ineffective measuring tools. This lack of superheat measurements results in air conditioners that are either undercharged or overcharged and in danger of compressor failure.
Superheat is defined as the difference between the temperature at which the refrigerant boils at a given pressure in the evaporator and the temperature of the refrigerant gas as it leaves the evaporator. In a worst-case scenario with low indoor heat load and the air conditioner still running, if overcharged, the refrigerant in the evaporator would remain in liquid form in the coil and back up into the compressor, steadily destroying it. In a properly tuned system, the refrigerant continues to boil and exits the evaporator as a gas even under the worst possible conditions.

A distinction must be made between systems which employ a TEV/TXV and those which have a "fixed restrictor"/"flow-rater". The superheat on a TEV/TXV should always be within a certain range regardless of the condition. On a TXV/TEV system that is starved, the superheat will go up above the range. But on an overcharged TXV/TEV system, the superheat will not go below the range. For this reason, to properly charge these systems you must charge to the subcooling.

However, on a fixed restrictor the superheat varies with the inlet to the evaporator wetbulb and outdoor drybulb. When the correct measurements are taken, the technician learns how much heat the refrigerant gas has picked up from the evaporator coil and gains insight into how the unit is operating. A large temperature difference (superheat) indicates that the refrigerant has turned to a gas a longer distance from the compressor than a lower superheat. With this information in hand, the technician can add or subtract refrigerant to meet a target superheat number.

The Four Key Measurements

In reality, using superheat measurements to determine the correct refrigerant charge is not that difficult and the savings in energy and potential repairs are significant. All that the technician needs is a basic knowledge and some modern measuring tools. The process requires only four measurements.

First, to find out the target superheat for a fixed restrictor system you will need to measure two parameters:

1. Outdoor air temperature taken from the air that is going into the condenser coil.

2. Indoor wetbulb temperature taken by a wetbulb thermometer that has been soaked in water and held in front of the indoor return grille or, better yet, just in front of the evaporator coil.

Air conditioner manufacturers display the target superheat temperature on or near the unit in the form of a chart. The target on the fixed restrictors varies with the indoor wetbulb and outdoor drybulb measurements. On the required superheat charts, the indoor wetbulb temperature is usually listed across the top and the outdoor drybulb along the side with the ideal target superheat displayed where the two intersect.

When the technician has determined the target temperature, he needs only two more numbers — the boiling point (saturation point) of the refrigerant at the pressure in the evaporator and the suction line temperature.

The boiling point is easy. You can measure the pressure at the evaporator with your pressure gauge and in most cases read the boiling point right on the gauge. If the boiling point for the refrigerant you are working with is not on the gauge, then you will have to look it up on a pressure-temperature chart.

To determine the temperature of the refrigerant in the suction line pipe, all you need to do is measure the temperature of the pipe.

When you have the two, to get the actual superheat, subtract the boiling point off of your gauges or charts from the actual evaporator superheat temperature. If the actual superheat is lower than the target, remove refrigerant, and if higher, add refrigerant. Always let the system stabilize and check again after adding or subtracting refrigerant.

The Difficulty Of Getting Accurate Results

Unfortunately, as many technicians can attest, it sounds a lot easier than it is. The problem is the three temperature measurements. They're not as easy to take as it would seem. While instrument suppliers have spent a lot of time developing better instruments, many have missed problems faced by field service technicians in the real world. These three temperature measurements are good examples.

Outdoor Air Temperature

When measuring the outdoor temperature, for example, temperatures can vary considerably in the area around the condenser. The only reliable place to take the outdoor temperature is right in front of the condenser coils and the thermocouple should remain there for a full minute to ensure accurate measurement. Holding the thermometer there for the whole minute can be a problem. One solution is the addition of an alligator clip to a beaded K-type thermocouple so that it can be readily fastened directly onto condenser grille and stay in place as long as needed. This will work with any meter that accepts a K-type thermocouple.

More accurate temperatures can be achieved by paying attention to subtleties. With the most common K-type thermocouple thermometers, there is a temperature reference junction inside the meter (the "cold junction") that is monitored by a thermometer inside the meter. Both the reference junction and the thermometer need to be at the same temperature to ensure an accurate reading. Some meters employ an adapter, with the reference junction inside this adapter. Any difference in temperature between the external reference junction in the adapter and the internal thermometer inside the meter will show up as an error.

By simply holding this adapter in your hand you can alter the reading that the multimeter displays. A solution developed places the reference junction and the thermometer inside the meter on a ceramic substrate so the reference junction and thermometer will be at the same temperature regardless of the ambient temperature.

High accuracy measurements for determining superheat are best taken with a clamp thermocouple for suction line temperature, a thermocouple with an alligator clip attached to the condenser grille for outdoor temperature, and a wetbulb sensor with a permanent cotton sock attached directly to the incoming air side indoor air measurement. (Photos courtesy of Fieldpiece Instruments.)

Wetbulb Indoor Air Measurement

Indoor wetbulb temperature measurement also presents a problem. The “wetting” material is difficult to find and also to affix on a thermocouple. Technical articles, manuals and educational texts suggest such things as moistened toilet tissue and paper napkins. One major instrument manufacturer suggests a piece of cotton shoe lace, thus sending technicians on a fruitless quest since modern shoe laces are made of synthetic materials and blends.

Fortunately, some meter manufacturers make a thermocouple made especially for taking wetbulb measurements. It includes a permanently attached “sock” which holds considerable water, has a large surface area for evaporation, and has intimate thermal contact with the thermocouple. Here, again, an alligator clip on the thermocouple makes a valuable contribution to accuracy by enabling the technician to clip the instrument directly on the indoor return grille or directly to the evaporator coil on the incoming air side. It can be left in place until it completely cools down in the air stream. It’s easy and reliable and can be used with any thermometer using K-type thermocouples.

Suction Line Measurement

The last measurement presents an even bigger source for potential errors. The suction line temperature cannot be measured with a simple pocket thermometer because the thermal contact with the pipe is not good enough and the thermal contact with the environment is too good. The resulting temperature would be somewhere between the pipe temperature and the air surrounding it. The trick is for the technician to find a way to measure only the pipe temperature.

One way involves the use of a standard beaded thermocouple with a Velcro strip. Cutting back the insulation on the thermocouple about an inch, the technician wraps the whole inch of bare wire around the pipe and holds it in place with the Velcro. Another method requires the technician to push the beaded thermocouple under the pipe insulation. For this to work, the insulation must be dry and fit tightly. In both of these methods, the amount of thermal contact between the thermometer and the pipe is still unknown and can vary with how snug the thermometer is to the pipe.

The most effective way to accurately measure suction line temperature requires a pipe clamp thermocouple. These units work with any meter that uses K-type thermocouples and provide excellent thermal contact by squeezing directly onto the pipe and providing good thermal isolation for the temperature sensor. This style of thermocouple snaps quickly and easily onto a pipe and maintains a reliable thermal contact.

The problem in determining superheat centers on getting accurate measurements in the first place. By keeping in mind the pitfalls involved in drybulb, wetbulb, and suction line measurements and by having the best tools available to get accurate results, the modern technician can easily determine the appropriate refrigerant charge for an air conditioner, given the conditions, thereby assuring efficient operation while avoiding serious damage to compressors.

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