Superheat & Subcooling

Sensible & Latent Heats

Made Simple

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The purpose of this article is to provide a simple explanation of these terms for those who desire a concise understanding as well as a review for those who understand the terms but want to review them. An understanding of these terms and the concepts related to them is essential to understanding the air conditioning and refrigeration mechanical – refrigerant cycle as well as being necessary to troubleshooting cycle problems.

Superheat:

Most materials can exist in three forms, solids, liquids and gases. Water is a common example. Water can exist as a solid (ice), a liquid, or a gas or vapor (steam). Only a gas or vapor (these are interchangeable terms), can be superheated. Let’s use water as an example as we explain these terms.

Water at sea level boils at 212 degrees F. When heated to 212 degrees F the molecules which make up water are moving at a high enough speed that they overcome the air pressure above the water. As additional heat is added to liquid water at 212 degrees, the water begins to boil. As the water boils it is changing state from a liquid to a gas. In addition, during the boiling process the temperature remains the same (212 degrees F). There is no change in temperature during a change of state. This phenomenon is true for all substances as they change state no matter how much heat is added. As long as the water is still boiling and not all the water has completely changed to a gas (steam) the temperature remains at 212 degrees F. This means that a thermometer placed in boiling water will remain at 212 degrees throughout the boiling process even though heat is added to cause the water to boil. This heat of boiling is called latent heat. The word “latent” is a Latin word for “hidden”. The heat added to the water is hidden from the thermometer since the temperature remains unchanged during the boiling process.

After all the water has changed to a gas or vapor (steam), then the addition of still more heat to the vaporized water or steam will cause the temperature of the steam to increase above it’s boiling temperature of 212 degrees. Any increase in temperature of the steam above it’s boiling point (212 degrees) is called “superheat”. Steam at 213 degrees F is superheated by one degree F.

Superheat is then any temperature of a gas above the boiling point for that liquid. When a refrigerant liquid boils at a low temperature of 40 degrees in a cooling coil and then the refrigerant gas increases in temperature superheat has been added. If this refrigerant changed from a liquid to a gas or vapor at 40 degrees and then the refrigerant vapor increased in temperature to 50 degrees F, then it has been superheated by 10 degrees.

We commonly think of boiling as always being accomplished by a liquid when it is hot. This is because we are familiar with boiling water. However, air conditioning and refrigeration systems use liquids (refrigerants) with much lower boiling points. If a liquid refrigerant boils at -10 degrees and is then warmed up to zero degrees, it is then a superheated gas containing 10 degrees of superheat. Heating that same refrigerant gas to +10 degrees means that it now has been superheated by 20 degrees.

Lowering the pressure over a liquid lowers the boiling point. There is less pressure above the liquid to overcome. That is why water at the top of a mountain may boil at 190 degrees (depending upon the altitude) rather than at 212 degrees F. By controlling the pressure over a liquid, we can control the boiling temperature. That is why a service technician monitors the pressures in an air conditioning system. The technician is actually monitoring the pressures and temperatures where the refrigerant is changing state.

Saturation:

Saturation is simply the term used to describe the point where a change of state in a substance is taking place. For water at sea level, the boiling temperature is 212 degrees F. Therefore, we say the saturation (boiling temperature) is 212 degrees. As soon as the temperature of the steam is heated above it’s “saturation” temperature, it has been superheated. Refrigerant that has boiled (turned into a vapor) at 40 degrees has a saturation temperature of 40 degrees. If the refrigerant vapor is heated to 41 degrees it is no longer saturated, it is then superheated by 1 degree. Remember, only a gas or vapor can be superheated. Superheat is any temperature of a gas or vapor above it’s saturation temperature.

Subcooling:

Subcooling is now easy to understand. Only liquids and solids can be subcooled. Subcooling is any temperature of a liquid or solid below it’s saturation temperature. Let’s use water as an example again. Liquid water at sea level has a saturation (boiling) temperature of 212 degrees F. If we were to add heat to the saturated water it would first boil away with no change in temperature (remember latent heat?) and then become superheated if still more heat were added to the vapor (steam) after it had all turned to a vapor.

Instead of boiling our 212 degree water by adding heat, we shall remove heat from the 212 degree water. As heat is removed from the liquid water it's temperature will drop below it's boiling (saturation) temperature. Water at 211 degrees has been subcooled by one degree F. If the temperature of the water is decreased to 180 degrees the water has been subcooled from 212 degrees to 180 degrees. That is, it has been subcooled by 32 degrees. When you drink 180 degree coffee, you are drinking a subcooled liquid!

Sensible Heat & Latent Heat:

Sensible heat is heat that can be measured by a thermometer. Anytime heat is added or removed from a substance and a temperature change occurs, a sensible heat change has taken place. Since both superheat and Subcooling are changes in temperature, they are both sensible heat processes.

When an air conditioning system cools air sensible heat has been removed. In fact, since the air is a gas or vapor and is heated far above it's boiling (saturation) point, it is superheated air. Yes, you are breathing superheated air as the air is hundreds of degrees above the temperature at which the gases which make up air would condense back into liquid form.

Superheated does not necessarily mean hot. And, subcooled does not necessarily mean cold. Superheat and Subcooling are determined by the boiling temperature of the substance and unlike water many substances have low boiling temperatures.

Recalling that latent heat is the heat which is added to a liquid to cause it to change from a liquid to a gas (boiling) without a change in temperature, let's go to the next step. When a gas or vapor is above it's boiling point it is said to be superheated. Cooling the gas removes it's superheat. When all the superheat is removed from a gas, the gas will condense back into a liquid. The heat removed from a saturated gas to allow it to condense back into a liquid is once again latent or hidden heat and is not a sensible heat process. That is, during the process of changing from a gas to a liquid it occurs at a constant temperature therefore a thermometer will not detect any temperature change. That is latent heat.

Air contains water vapor or moisture. Humid air is not comfortable. Too much humidity (moisture) in air is uncomfortable. As air containing too much moisture passes over a properly designed, installed and operating air conditioning system, the air is cooled by the air conditioning coil (evaporator) located at the indoor blower section. If the air containing the moisture is cooled to the condensing temperature (dew point) of the moisture in the air, some of the moisture will condense and deposit on the coil and fins of the cooling coil. Since the water vapor is changing from a gas or vapor to a liquid, this is a latent heat process. The condensed water should run off the coil and be drained away.

A properly operating air conditioning system both cools (a sensible heat process) and dehumidifies (a latent heat process) the air. For example, given a 3-ton residential air conditioning system, a percentage of the total capacity of the system is utilized to cool the air while the remaining percentage of the total capacity is used to dehumidify the air. Properly controlling both the temperature (sensible heat) and the humidity (latent heat) will provide the optimum comfort for the occupants.

Measuring Heat:

Latent heat cannot be directly measured as we can sensible heat. In order to properly adjust, troubleshoot and repair air conditioning equipment it is necessary that we understand heat and how to measure heat.

Superheat and Subcooling are both sensible heats and therefore can be measured with a thermometer. Superheat and Subcooling are also temperature differentials. That is, each is a number of degrees a gas or liquid are above or below their saturation temperatures. It is essential that a service technician be able to accurately measure these differentials and diagnose system operation from them.

A high quality, accurate electronic thermometer capable of measuring temperature differentials is almost an essential tool for the technician and highly useful to the interested homeowner. An example of such an instrument is **Bacharach's "Dual Channel. Model TH3000, digital thermometer" with data hold and max hold functions.**

Another very useful digital thermometer capable of performing additional air quality test functions is **Bacharach's "Comfort Check" 100 & 200 model Indoor Air Quality Analyzers.** Essential for anyone interested in investigating or monitoring indoor air quality.

Conclusion:

In an effort to keep this article as short as possible, yet informative, a great deal of related material and concepts have not been addressed. Future articles will address these topics including the important issues related to indoor air quality concerns and how to rectify them.