# DeSaturation

**Luvata's** new "DeSaturation" coil is two-coils in one. It is a combination cooling/reheating coil in one common case that both dehumidify and reheat the same air to a desired leaving air temperature and humidity level in low cooling applications.

Why is such a coil needed and what are the advantages that can be realized from the use of this coil? We will try to answer these two simple questions.

First, let's refresh our memories with some definitions of the terms used in HVAC system design:

A. Dry Bulb temperature is the ambient temperature of the air and is an indicator of heat content.
B. Wet Bulb temperature represents how much moisture the air can evaporate.
C. Relative Humidity is the ratio of the actual amount of water vapor in the air to the amount of moisture it could hold when saturated, expressed as a percentage. Since moisture holding capacity increases as air is warmed, Relative Humidity is a relative measure. Relative Humidity indicates the moisture level of the air compared to the air's moisture-holding capacity.
D. Saturation is when the air holds as much water vapor as possible at a given temperature.
E. Dew Point indicates the temperature at which moisture will begin to condense out of the air stream. This temperature indicates the maximum temperature the cooling fluid must be in order to dehumidify the air.
F. Humidity Ratio is the measure of the actual physical amount of water in the air. It is expressed a ratio of the pounds, or grains, of water for every pound of dry air

If the Dew Point temperature is equal to that of the air temperature, the air's dry bulb temperature is equal to it's wet bulb temperature, thus the air is saturated. Therefore, unless in extreme supersaturated conditions, the Dew Point would not be greater than the air temperature. When the air is cool by a fluid whose temperature is below the dew point, this maximum amount of water vapor that the air can hold begins to decrease and the water vapor begins to fall out of the air in the form of "dew" or condensate. As the moist air's temperature begins to fall, its dew point falls and more water vapor is condensed. The amount of water that is condensed out of the air is a direct relation to how far the air falls below its original dew point temperature.

This can be seen clearly on a psychrometric chart due to the fact that the dew point line is parallel to the humidity ratio line. As stated earlier, the humidity ratio is defined as how many pounds, or grains, of water are held for every pound of dry air. Since these lines are parallel, as the dew point is decreased, at the same time, so is this humidity ratio; therefore, by definition there must be a decrease in the water content in the air. This water must go somewhere so it condenses on the cooling surface.

Summarizing these terms, Dew Point is the temperature you must cool air to (at a constant pressure) in order for the air to become saturated. This is the state of 100% Relative Humidity, which is termed relative due to the fact that it is dependant on the temperature of the air. An example of this would be that air at 90°F with a relative humidity of 80% has a much higher physical content of water then air at 40°F with the same 80% relative humidity. The humidity ratio is a more clear measure of the amount of moisture in the air.

The temperature of air is lowered for comfort or for specific design criteria such as the temperature required in operating rooms and laboratories by the use of heat exchangers. A heat exchanger is a device used to transfer heat from one flow stream to another. In cooling coils, we exchange heat between streams of water or refrigerant and air. The thermal energy gain of one stream must equal the thermal energy loss of the other stream. This thermal energy change can either be a sensible heat change or it could be both sensible and latent heat change. The sensible heat exchange is that which directly results in a change of dry bulb temperature. It is called "sensible" because the result of this is a temperature change that can be felt, or sensed. The latent energy exchange is that which occurs due the energy required for a fluid to change phase, in this case for water vapor to convert to liquid condensate. It is called “latent” because it does not reflect in a change in the dry bulb temperature so it cannot be felt.

In any heat exchanger, the outlet temperature cannot be higher than the highest inlet temperature, nor can it be lower than the lowest inlet temperature. The heat exchanger can use either parallel flow, counter flow or cross flow, depending on the exchanger configuration. We will use counter flow relative to coil design discussed later in this article.

Cooling coils are a form of heat exchanger. They are used to both cool the air and to remove moisture from the air. For this discussion, the flow inside of the coil is chilled water, and the flow outside of the coil is moist air that is to be cooled. Dehumidification is when a moist air stream is cooled to a temperature below the Dew Point causing moisture to condense out of the air stream.

When chilled water is used as the cooling media in coils, aluminum fins on copper tubes are normally used. The advantages of using finned coils as the heat exchanger for cooling are:

1. The complete separation of the cooling fluid from the air stream.
2. High velocities in the air stream are only limited by the amount of condensation that is entrained in the air stream.
3. Coil configurations can be adapted to meet the requirements of many different cooling apparatus.
4. A coil provides a compact heat exchange surface.

Thirty years ago, the common design criteria was the lowering of a mixed air temperature to 55°F dry bulb and 54°F wet bulb with 45 °F water and a 10 degree rise in the water. Today, as surgeons demand lower and lower operating room temperatures, the design criteria has shifted to lowering the mixed air temperature to 45°F dry bulb and 44°F wet bulb using 40°F water. As an example, to reach this design of 45/44°F leaving air temperature to the space, using a draw-thru air handling unit, (harder to achieve as motor heat is included in the air stream) we must cool entering air at 85.4/68°F to 42.5°F saturated. When this happens condensation, or water droplets form on the leaving airside of the coil. Until now, the common procedure to eliminate these water droplets would be to add an additional reheat coil downstream of the cooling coil, or to install moisture eliminator plates on the leaving air side of the coil. The additional coil would require additional piping to bring 180°F water to the reheat coil, or at a minimum the addition of air pressure resistance from the eliminator plates.

Before we explain the advantages of the new ***Luvata Desaturation Coil***, we need to review common coil terminology used in the manufacturing of coils as heat exchangers.

1. Counter flow in cooling coils is when the entering (warm) air stream passes over the (warmer) leaving water stream. This is when the cooling fluid enters at the leaving airside of the coil. Counter flow is the highest efficiency water coil configuration.
2. Water Pressure Drop (WPD) is the allowable frictional resistance in the cooling fluid medium (water side) thru the tubes, and is measured in Ft. of Water. Coil tubes are designed to be self-draining by gravity and to use the minimum pressure drop to aid in water distribution without excessive pump head.
3. Air Pressure Drop (APD) is the coils resistance on the air side and depends on tube patterns, fin geometry, fin density, face velocity and moisture held on the face of the coil.
4. Circuitry is the mechanical arrangement of the tubes, which configure the number of times the water flow passes through the air stream. The number of passes through the air stream also determines whether the water connections are on the same end of the coil or on opposite ends of the coil. The tube passes are usually interconnected by return bends to form the serpentine arrangement of the circuit. The most common circuits are single (full), half and double circuit. In a single circuit coil, all of the tubes in the first row of tubes get feed entering chilled water. Likewise, in a half circuit coil, half of the tubes in the first row get fed, and in a double circuit, all of the tubes

in the first two rows of the coil get fed entering chilled water. The lower the serpentine the higher the capacity of the coil but the higher the water pressure drop as well.

Now, back to the advantages of using the new ***Luvata Desaturation Coil*** design. In our previous example, to cool a mixed air temperature from 85.4/68°F to 42.5°F saturated requires a 10 row deep coil. This ten row coil will have a double circuit (with every tube in the first 2 rows being feed entering chilled water) which makes the coil an opposite end connection coil. Water entering the coil (on the front end of the coil) at 40°F will absorb heat raising the water temperature to 49.8°F (on the back end of the coil). Because our air stream is now saturated (42.5/42.5°F), water droplets form on the leaving side of the coil and could become airborne. Incorporating a 2 row, double circuit coil, for reheat within the same casing brings the water connection back to the front end of the coil. Since we only need to move off of the saturation line, a minimum temperature rise is required. If we enter the 2-row portion of our coil with the 49.8°F temperature water we can raise our leaving air temperature to 45/44°F (our desired design point) and still have a leaving water temperature of 49.55°F. One of the best features of this coil design relates to the header arrangement on the coils. The water pressure through a coil header can account for as much as 30% of the total water pressure drop through the coil. In a normal 2 coil arrangement, each coil would have 2 headers, one for the supply and one for the return of each coil. To reduce the overall water pressure drop through the coil, we have eliminated (2) headers by using extended return bends on the backside of the coil. Because our coil has an opposite end circuit, we rotate the last two rows of return bends in the 10 row cooling coil directly into the two rows of the reheat coil, and eliminate the need for two headers on the backside of the coil. The water pressure drop through the return bends is considerably less than what it would have been through the two headers. This coil design incorporates several other advantages:

1. As we mentioned above, by eliminating the two headers, we have reduced the water pressure drop, which equates to a cost savings in reduced pump horsepower.
2. By using the leaving water from the cooling coil portion of the coil, we do not need 180°F water. Since we are moving off of the saturation line, minimum reheat is required to reach our desired leaving air temperature. Any additional piping normally required for a second coil has been eliminated.
3. Water carry over is eliminated as the reheat portion of our coil also serves as a plate fin eliminator.
4. We can use two different fin patterns in the coil-pack thereby reducing air pressure drop, which equates to a cost savings in reduced fan horsepower.
5. With the elimination of the second set of coil connections, we eliminate all control valves and pipe components associated with the second coil.
6. By eliminating the need for the second coil, we save air handling space and coil accessibility.
7. Since various coil circuits are available, the depth of the coil (in the direction of air flow) can be adjusted to achieve the desired results.
8. Materials of construction for the coil (because of conditions of the air or water) can vary without effecting performance.
9. This coil will be ARI tested and labeled.

Final Summary:

The two most important items to remember from this discussion are that this coil can be used anywhere low temperature air is required and low temperature water is available, and second, the coil must be circuited for opposite end connection. If fogging occurs due to moisture carry-over, the droplets will be knocked out of the air stream by the reheat portion of the coil.