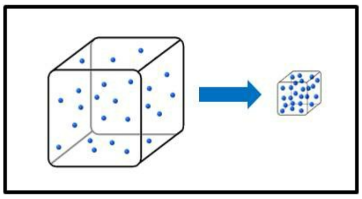
Blake & Pendleton

# Managing Condensate

## Dealing with Water in Your Air Systems

Toll Free: (800) 333-6650

All compressed air systems create some level of condensate through the basic function of compression. As air is squeezed into a smaller space, the naturally occurring moisture in the air, or relative humidity (RH), is compressed and during compression, water vapor molecules bond together to form droplets. In areas where the average RH is low, condensate may not be a big issue. However, here in the southeastern USA, RH levels can average over 95% on any given day. A 75 horsepower compressor can generate 20 gallons of water in an 8 hour shift. This makes airborne moisture a serious issue. Even small air compressors will generate several gallons of water each day operating in environments with high humidity.



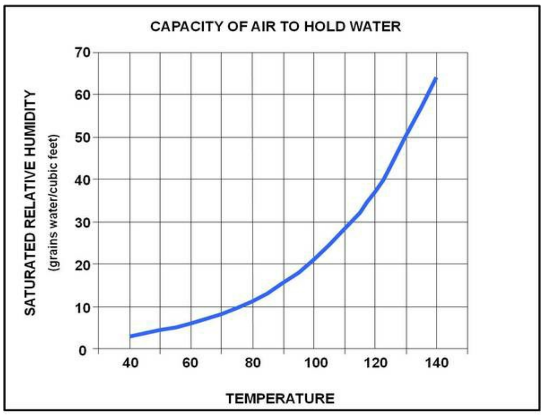
**It is very important to properly manage the water in your compressed air system.** Poor water or condensate management can result in process contamination, component failure and high pressure differentials. In other words, improperly managed compressed air system water is costly in terms of time and money.

If you could see compressed air at the discharge of an air compressor, it would look like fog. Discharge compressed air is fully saturated with moisture, but because that airstream is hot, moisture stays in a vapor form. In a lubricated screw compressor for example, sealing oil is separated first through a separator element and is returned to an oil sump, while the moisture-laden compressed air travels to an after-cooler.

After-coolers can be cooled with air or water, and the choice of which to use is really site specific. Both types of coolers are designed to reduce 170+ degree F compressed air discharge temperatures to 100 degrees F or lower and in doing so, allow over 60% of the entrained moisture in the air to change from a vapor state to a liquid state and become condensate. This condensate is separated from the air stream through a moisture separator and sent to a condensate drain trap where it is ejected from the system.

The process of cooling compressed air with an after-cooler is based on having sufficiently cool air or water to allow for the cooling of the compressed air stream. Most after-coolers have an ***approach temperature*** rating that defines how close that particular model will cool the air stream in relation to the local ambient temperature. For example, if an after-cooler is rated for an approach temperature of 15 degrees F and 80 degree F ambient air is drawn across that cooler, it is expected that the compressed air discharge temperature will be 95 degree F. If 95 degree F air is drawn across the cooler, the compressed air discharge temperature will be 110 degrees F. The same hold true for water cooled after-coolers. Most manufacturers recommend 80 – 85 degree F cooling water to an oil-flooded rotary screw compressor, allowing for a compressed air discharge temperature of 95 to 100 degrees F.

If the compressed air stream is not cooled to the desired 100 degrees F, then adequate moisture has not been removed and we are sending wetter air to the compressed air dryer. In many cases, the cooling air or water supply is not sufficiently cool to lower the compressed air stream temperature to 100 degrees F or lower. Therefore, we need to take this into consideration when sizing system air dryers. Many standard refrigerated and desiccant air dryer designs use 100 degrees F inlet temperature as the design point for proper functioning. Manufacturers will refer to the “three 100’s” as their design conditions: 100 degrees F inlet air temperature, 100 PSIG inlet air pressure and 100 degree F maximum ambient temperature. At these conditions, standard dryer ratings for maximum air flow will be in effect. If any of these conditions change (higher temperature or lower pressure), the performance rating of the dryer will also change.




A simple rule of thumb, but also an indicator of how much moisture is present in higher temperature compressed air, is for every 20 degree rise over 100 degrees F in air temperature, the amount of moisture air can hold is increased by 50%. For example, if a system has a demand of 1,000 SCFM at 100 degrees F and 100 PSIG, a dryer rated for 1,000 SCFM will do the job. If the ambient temperature is 95 degrees F and the compressed air stream temperature is closer to 115 degrees F, the dryer would need to be upsized by 25% to accommodate the higher moisture content. In this case, the dryer would have to be sized for 1,250 SCFM to get the rated performance and moisture removal.

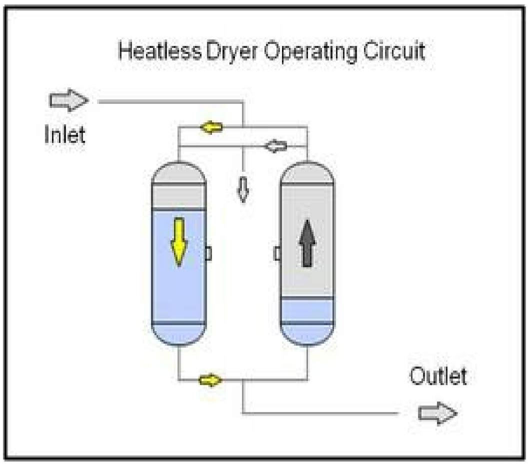
As mentioned, there are two common types of compressed air dryers, refrigerated and desiccant. There are others but these are the two most common in industrial and process applications. Within each of those groups there are various styles of dryers to best meet particular process needs, but a discussion of the differences would be helpful. A refrigerated compressed air dryer uses a compressor-driven refrigerant system. Entering compressed air is first pre-cooled with a heat exchanger and then it is chilled to a temperature between 34-39 degrees F. The chilling process drops the compressed air temperature and allows moisture to condense into liquid water. Since the incoming air stream is saturated with moisture, the lowest temperature it reaches is its dew point. At this temperature, the air stream is still saturated with moisture (although less than before) and no additional liquid water will be generated. Is the air completely dry? No, if we continued to chill the air stream to 0 degrees F we would see more condensation, but below 32 degrees F ice would form would freeze up the internal passages of the dryer. We are limited to staying above the freezing point in refrigerated type dryers.

Once moisture is chilled and forms condensate, air stream passes through another moisture separator that will separate and remove the accumulated liquid water. For most users, a refrigerated dryer is all that is needed for adequate moisture removal. In these applications, temperatures around compressed air supply piping and tubing never get down to below the dew point temperature of the compressed air stream. No moisture should be present in these systems as long as the air temperature does not drop below the dew point established at the dryer.

There are specific process and production requirements that prevent the use of a refrigerated compressed air dryer. In addition, if a refrigerated dried air system with a questionably performing dryer has compressed air lines that run outside, there may be issues during winter conditions. During these periods, outside temperatures will drop below freezing and could reach the dew point of the compressed air system. Additional water can condense out and turn to ice at these times. Ice can create a plug in the line, choking off the flow of compressed air. In these situations, use of a desiccant style dryer should be considered.

Just like refrigerated dryers, desiccant dryers are available in various designs to best meet specific process needs. A desiccant air dryer is typically used when a 35 degree F dew point is not acceptable. To reach dew points below this, manufacturers use a product known as desiccant. Desiccant comes in a bead form typically with one-fourth or one-eighth inch beads. The most common material for desiccant beads is activated alumina. Activated alumina adsorbs moisture in the air stream and this moisture coats the outside of the beads. The adsorption process starts a reaction that actually heats up the beads. The desiccant continues this process until it can no longer hold any additional moisture. At this point, the desiccant must be regenerated (dried) before it is useful again. Standard dryers using activated alumina desiccant can attain dew points down -40 degrees F.

Desiccant dryers are typically built with two vertical pressure vessels of equal size, both filled with desiccant. Wet compressed air flows through one tower is dried. At the same time, the other tower is going through a regenerative process and is being dried out. In many designs, dry compressed air from the on-line tower is used to regenerate the off-line tower. After the off-line tower is regenerated, it will re-pressurize and become the on-line tower. The moisture filled on-line tower switches to the regeneration state. This is a continuously repeating cycle.




The moisture that is on desiccant beads can be driven off by heated air or a portion of the very dry air that is being produced by the on-line tower. In either case, trapped moisture is returned to a vapor state and is carried out of the vessel to atmosphere through a silencer/muffler. In this style of dryer you do not have a condensate stream at the dryer discharge with moisture separators and drain traps.

Desiccant dryers can be designed to reach very low dew points, as low as -100 degrees F, for applications that require extremely dry air. Compressed air with a dew point of -100 degrees F can be used to replace nitrogen in applications where nitrogen is being used only for its dry properties. Just like refrigerated dryer applications, inlet air temperature will determine the amount of moisture in the air. Inlet temperatures that are higher than nominal will require adjusting dryer size to meet system requirements and maintain dew point performance.

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