CSC Cal Supply Company, Inc.
AIR COMPRESSOR SALES AND SERVICE

The Basics of Compressed Air Dryers

To get the best performance from your compressed air system it's necessary to control the amount of water present. Compressed air contains water in both liquid and vapor forms. Liquid water washes lubricant from air operated equipment and accelerates wear. It also mixes with substances that compressed air is used to move and degrades the performance or results of the process. Water mixing with paint in a spray gun ruins the paint job. Water mixing with sand blast media creates clogs in hoses and nozzles. The vapor form of water doesn't cause problems for the most part – unless it's cooled down to a temperature at which it condenses into a liquid. Unfortunately, every time compressed air is expanded through an orifice – like the throttle of an air tool, or a control valve or a spray gun, it experiences some cooling. If it's cooled enough, you get liquid.

The temperature at which water vapor in compressed air becomes liquid is called the pressure dew point. Everyone who has ever heard a weather report in the summer time is familiar with atmospheric dew point. If the weather man says that it's 82° outside and the dew point is 78° or the relative humidity is 88%, you know that it's very humid and is likely to rain if the temperature falls much. If you have cold drink you will see the sides of the glass become wet and start dripping water all over the table. When we talk about pressure dew point we describe the same process, except it's happening inside of a pressurized pipe or tank.

There's no way to compress air without compressing water along with it. No matter what season of the year we're in, or whether or not we're in air conditioned space, there will always be some humidity. We can't live comfortably without it. Another important thing to remember is that the hotter air is, the more water it can hold.

The big question is: How dry does compressed air need to be for what you need it to do? Bearing in mind that drying compressed air costs money, and that the dryer you make it, the more it costs, you will want to make the right choice.

Aftercooler
(pressure dew point = cooling medium temperature + approach temperature)

The compressor's aftercooler is the first step to dryer air. It is placed at the compressor's air outlet and uses either ambient air or water to cool the compressed air and condense some of the water vapor in the compressed air into a liquid that can be removed with a water separator. Air cooled aftercoolers look similar to a car's radiator or the condenser in an air conditioner. Shell and tube heat exchangers are commonly used for water cooled aftercoolers.

Aftercooler performance is rated by approach temperature, which is to say how closely the compressed air leaving the aftercooler will approach the temperature of the cooling medium used. For example, if an air cooled aftercooler is rated for a 10°F approach temperature, and the temperature of the ambient air is 90°F, the temperature of the air leaving the aftercooler will be 90°F + 10°F, or 100°F. If a water cooled aftercooler rated for a 10°F approach temperature was being used with 60°F from the city water supply the compressed air would be cooled to 70°F, with a lot more water having been condensed out of the compressed air. Water cooled aftercoolers were very popular when water and sewer costs were inexpensive. This is no longer the case. Air cooled aftercoolers are the most economical choice and are standard equipment on many compressors and an option on others. Buyer Beware! When comparing aftercoolers find out what the approach temperature is that they are rated for. The lower the approach temperature is, the more water will be condensed out of the compressed air.

Mechanical Water Separators
(pressure dew point = compressed air temperature)

These are mostly placed immediately downstream of aftercoolers but also can be placed in locations where compressed air has been subject to cooling, like after long runs of pipe through cool locations. Wet compressed air enters the separator and passes through a set of vanes that increase its' velocity and make it spin in a vortex. Centrifugal force causes liquid to fly out of the compressed air stream and run down the inside of the filter bowl, where it can be drained off. Air leaving a water separator is better than air that has not passed through one, but the odds are that you will still have wet air when you use it.

Deliquescent Dryer
(pressure dew point = incoming compressed air temperature less 20°F)

A deliquescent dryer is basically a tank full of salt tablets. As the compressed air passes through the salt, the salt attracts water and dissolves into a brine that can be drained off. These are the least expensive dryers to purchase and maintain because they have no moving parts and require no power to run. The operating cost consists of the cost of more salt tablets plus the freight to bring them in.

The pressure dew point of the compressed air leaving a deliquescent dryer varies with the temperature of the compressed air entering the dryer. In summer, if you have compressed air entering the dryer at 90°F, the pressure dew point of the exiting compressed air is 70°F. This is better than not having a dryer but not by much. In winter these dryers work much better and can be used to prevent freezing of condensate in piping that is exposed to outside temperatures. The fact that they need no electricity to run and the water that they they remove from compressed air is part of a salt brine with a lower freezing point also makes them desirable for winter operation outdoors. By controlling the temperature of the compressed air entering the dryer, they can keep freeze-ups from happening down to temperatures of 12 to 15°F.

The salt used to make the tablets for deliquescent is not common table salt, and is formulated to be less corrosive to metal. However, the issue of corrosion is still there. Eventually the dryer will corrode and need to be replaced. An afterfilter to capture any salt particles that the compressed air may pick up as it passes through the dryer will prevent piping downstream of the dryer from being corroded.

Refrigerated Air Dryers
(pressure dew point = 35°F or 50°F depending on the model selected)

This are by far the most popular type of air dryer. They are reasonably priced, economical to operate, provide a stable pressure dew point and do not require much maintenance. Most provide a pressure dew point of 35°F, but some less expensive models with smaller refrigeration systems are rated for the higher dewpoint of 50°F. There are two types of refrigerated air dryers: Cycling and Noncycling. The thing that both have in common is that they use a refrigeration system to cool the compressed air to a temperature as close to freezing as possible in order to condense out as much water as possible. They incorporate a mechanical separator to remove the condensed water before sending the compressed air out to the plant. Most refrigerated dryers also contain a heat exchanger called a precooler/reheater which uses the cold air leaving the dryer to pre-cool the hot, wet air entering the dryer. This reduces the load on the refrigeration compressor and prevents the piping from “sweating” in humid areas. Refrigerated air dryers require electricity to operate and must be kept in areas that are maintained above freezing.

Cycling Refrigerated Air Dryers

Cycling refrigerated dryers have refrigeration systems that run when cooling is needed and shut off when it is not. This concept is very similar to the refrigerator at home. If you open the door you will eventually hear the refrigeration system start. After you close the door the refrigeration system will continue to run for a while and shut off. If you open the door less, the refrigeration runs less. The refrigeration also runs less in winter than summer because cooler ambient temperatures cause less cooling loss through the walls of the refrigerator.

The most popular and reliable cycling dryer is the Thermal Mass type. The refrigeration system cools a large, heavily insulated tank full of propylene glycol antifreeze and water to a temperature close to freezing. This cold fluid is used to cool the compressed air to condense the water out of it. When the cold fluid warms up a thermostat turns on the refrigeration compressor and cools the fluid down again. The benefit of a thermal mass cycling dryer is that the refrigeration system only runs as much as it has to. If you use less compressed air, or the ambient temperature is cooler, you will use less electricity and put less running time on the refrigeration compressor and condenser fan motor(s). The electrical savings from cycling dryers can add up to a lot of money. The downside to cycling dryers is a higher initial purchase price. However, the electrical savings often pay this back very quickly. Better yet, many power companies offer rebates for energy efficient equipment which helps to offset the higher purchase price.

Noncycling Refrigerated Air Dryers

Noncycling air dryers have refrigeration compressors that start as soon as you turn the dryer on, and don’t stop until you turn the dryer off. They are less expensive to buy than cycling dryers and are a good choice for applications where they will be constantly at full capacity. However, during periods of low compressed air usage they can experience problems. Since the refrigeration compressor is running constantly there is cooling taking place constantly. If there isn’t enough heat being provided by incoming compressed air temperature in the dryer could fall below freezing,which will cause water condensed from the compressed air to freeze. At best this will mean an internal blockage with ice that shuts off your compressed air supply. At worst you get the blockage plus a split tube or heat exchanger caused by the expansion of water when it freezes. To prevent this from happening noncycling dryers are equipped with a device called a hot gas bypass valve, which sends the heat that the refrigeration compressor would normally discharge to atmosphere back to the cold side of the system to keep it from freezing. As long as this valve operates properly you won’t have a problem. If it fails, the dryer will freeze.

Desiccant Air Dryers
(pressure dew points as low as –100°F)

Desiccants are substances that attract and hold water very well. When you purchase a product that could be damaged by the presence of water you often find a little envelope full of what looks like small beads packed inside the box. This is desiccant. Two types are commonly used: activated alumina and silica gel. Unlike the salt tablets used in the deliquescent dryer, these desiccants don't dissolve when they absorb water. They fill up with as much water as they can hold and maintain their shape. Once they're full they need to be replaced or be regenerated (have the water removed). Some desiccants are treated with chemical indicators to change color when regeneration or replacement is needed.

Another name commonly used for desiccant dryers is "Twin Tower" dryers. This is because each dryer consists of two towers filled with desiccant, with each tower being capable of handling the rated flow capacity of the dryer. While one tower is drying compressed air, the other is being regenerated.

Desiccant dryers are used primarily where very low dew points are required. The most common ratings are at pressure dew points of –40°F and -100°F. Depending on size, their initial purchase cost can be less than or more than a refrigerated dryer. Operating cost is a more serious consideration with desiccant dryers. You don't want to use them unless you really need the low dew point.

Operating cost of these dryers varies with the method used to remove water from (regenerate) the desiccant. This process is referred to as "purging" and the three most common methods used are (1) Heatless purge, (2) Heated purge and (3) Blower purge. What all three methods have in common is that air is used to dry out the desiccant and carry the moisture to atmosphere.

Heatless Regenerative Dryers

Heatless regenerative dryers take a portion (about 15%) of the dry compressed air leaving the dryer and pass it through the desiccant of the tower that is being regenerated to abosrb the moisture from the desiccant and carry it out of the dryer. This is the least expensive regenerative dryer to purchase and the most expensive to operate. The reason for the high operating cost is the amount of expensive compressed air that is required for purge.
A dryer of this type that is rated for 500 CFM will use about 100 CFM for purge. 100 CFM is the output of a 25 hp air compressor. A comparably sized refrigerated air dryer would use a total of about 5 hp. There are optional controls available to make these dryers more energy-efficient.

Heated Purge Dryers

Heated purge regenerative dryers take advantage of the fact that hot air can hold more water than cold air. These dryers take about 5% of the dry compressed air leaving the dryer and pass it through an electric heater before sending it through the wet desiccant bed of the tower that is being regenerated. A 500 CFM heated purge dryer will use 25 CFM (7½ hp worth) of compressed air and a 4½ kw (6 hp worth) heater. The higher cost of this dryer is offset by energy consumption of a little more than half (13½ hp) of that used by the heatless dryer. There are also optional controls avaliable to make this dryer operate more efficiently.

Blower Purge Dryers

Blower purge dryers use no compressed air for regeneration. A blower mounted on the dryer sends atmospheric air through an electric heater which and then through the wet desiccant bed that is being regenerated. A 500 CFM blower purge dryer uses a 12 kw (16 hp worth) heater and a 3 kw (4 hp worth) blower. In this size the blower purge dryer is still more efficient than the heatless dryer but not as efficient as the heated purge dryer. In larger sizes this may not be the case. Blower purge dryers are also useful in situations where there is not enough excess compressor capacity to feed production and dryer purge at the same time.

Membrane Air Dryers
(pressure dew points to –40°F)

These dryers use pass the compressed air through a membrane with pores large enough to allow air molecules through but not large enough to allow water molecules through. A purge flow of dry compressed air is passed over the membrane to pick up the collected water and carry it out of the dryer. The lower a dew point is needed, the more purge air is required. These dryers are limited in sizes and are usually installed on small, point of use applications.