CANADIAN PURCELL MACHINERY LTD.
"A World of Compressed Air & Gas Solutions"

TECHNICAL BULLETIN

SELECTING A COMPRESSED AIR DRYER

INTRODUCTION

Having an understanding of why water forms in your compressed air piping system will help you in evaluating the type of air drying system which will best suit your specific needs.

The air we breathe contains water in a vapor form. The same humid air we breathe is taken into your compressor and compressed for use in your plant.

As the air is compressed, the temperature of the air rises and the hotter the air, the more moisture it can hold. Because the compressor usually presses the air to about one-eighth of its original area, the amount of moisture in the original area must now be contained in a much smaller area.

The amount of moisture contained in the air will vary with temperature, pressure and relative humidity of the ambient air. It will however surprise you to learn that a 25 HP air compressor delivering 100 SCFM at 100 PSIG with an inlet air temperature of 80^{o} F and a relative humidity of 70% will pump a little more than 19.5 gallons of water into the system in an 8 hour day. (See attached chart).

The term pressure DEW POINT is often used when talking about moisture in compressed air. The pressure dew point is the temperature at which additional moisture will condense out of the compressed air.

Most standard manufacturing plants will require a dew point at line pressure of 35 to 50^{o} F. some applications, such as those where lines will run outside during the colder winter months, will require even lower dew points (-40^{o} F.) to prevent line freezing.

Several types of equipment are commercially available to remove this water before it enters the piping system however, when selecting a compressed air dryer, the user must be cognizant of the capabilities and actual operating costs of each type.

Before selecting a compressed air dryer you should answer the following questions:

1. What volume of air will be flowing through the dryer?
2. Is the compressed air usage intermittent or continuous?
3. What will be the maximum temperature of the compressed air entering the dryer?
4. What will be the normal pressure of the compressed air entering the dryer?
5. What is the lowest ambient temperature the compressed air piping distribution system will be exposed to?
6. What is the ambient operating temperature range the dryer will operate in?

Most dryers are rated at 100^o F. inlet air temperature – 100 PSIG inlet air pressure; 100^o F. ambient – but be sure, when you compare for conditions other than these, you will have to re-rate.

When selecting a dryer it is a good idea to keep certain realisms in mind:

1. Saturated air at 100^o F. holds TWICE as much moisture as saturated air at 80^o F. Utilizing and specifying the coolest possible inlet air temperature to the dryer, no matter what type, will minimize the initial cost and operating cost.
2. Operating pressures also play a large part in the available moisture content of the inlet compressed air. Saturated air at 80 PSIG contains approximately 20% MORE MOISTURE than saturated air at 100 PSIG at the same temperature conditions. Operating at the highest practical pressure will result in smaller and lower cost dryers.
3. A HIGHER allowable DEW POINT will also allow the utilization of a smaller dryer or lower operating costs. For example: if a 55^o F. pressure dew point is allowable as opposed to a 30^o F. pressure dew point – then 30% more air can be handled with the same amount of cooling in a refrigerated dryer.

AIR LINE FILTERS

Standard Particulate Filters

It should be noted that air line filters are not actually dryers as they do not change or lower the dew point, nor will they remove moisture that is still in a vapor form. When installed in the piping system, they are designed to simply remove pipe scale as well as some of the moisture which has condensed and is therefore already in the liquid form.

Filters should be considered more of a moisture separator than a drier.

As air enters a typical filter bowl, a curved deflector directs the incoming air in a downward swirling pattern. Centrifugal force hurls the larger solid and liquid particles outward where they collect on the inner surface of the filter bowl. The baffle prevents turbulent air in the upper bowl from re-entraining the water and carrying it downstream.

The dry, cleaner air follows a convoluted path through the filter element, where finer solid particles are filtered out. Finally, filtered air passes up the centre of the element and out the discharge port.

Air filters remove impurities in two operations: dynamically by centrifugal force, which throws out heavier particles and entrained water; and statically through the filter element itself, which filters out the small particles.

Standard filters will generally use an element, which is rated at between 3 – 20 microns.

Coalescing Filters

These high-efficiency filters operate on a different principle than standard air filters.

Pre-filtered air flows into the centre of the cylindrical element. As it flows through the element, particles are captured by three different mechanisms: direct interception as particles impinge on the fibers; inertial impaction as particles are thrown against fibers by the turbulent air stream; and diffusion as smaller particles vibrate with Brownian movement to collide with fibers and other particles. As a result, coalescing elements can capture particles smaller than the nominal size of the flow passages through the element.

Collected liquid migrates to the crossing points of the fibers where larger drops form or coalesce. Pressure differential through the element then forces these drops to the downstream surface of the element where they gravitate downward to the sump.

The filtered air then exits through the outlet port.

Coalescing filter element will generally be rated at between .1 and .3 microns and may be as fine as .01 microns.

SEPARATORS

Although similar to filters, separators use centrifugal force to separate the moisture, rather than a filter element. Liquid droplets are forced out of the air stream as the air is caused to spin or change direction. Separators remove heavy liquid loads and are effective on larger water droplets. They are not, however, effective on sub-micron oil aerosols.

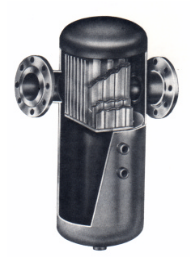

Figure 1
Separator

AFTERCOOLERS

Aftercoolers and Separators

Air-cooler or water-cooled aftercoolers in conjunction with a good quality centrifugal separator and automatic condensate drain are the first line of defense against moisture in compressed air systems. By decreasing the compressed air temperature they cause some of the entrained water vapor to condense. The condensate is then removed from the air stream by a mechanical moisture separator and a drain trap.

Approximately 60 – 65% of the entrained water would be removed by a standard air-cooled aftercooler operating in an ambient temperature of 70 – 80^{0}F. The aftercooler usually brings the air temperature down from the compressor discharge temperature of 180 – 250^{0}F to approximately 95 – 100^{0}F. That means that anytime the temperature of the compressed air will fall below 95 – 100^{0}F, additional moisture will condense out of the air.

These aftercoolers should be installed in the system regardless of what additional air dryers are to be purchased since a substantial capital cost saving will be realized by allowing downstream drying equipment to be more moderately sized.

In many applications the installation of an aftercooler without additional downstream drying equipment will offer adequate drying.

It should be noted however, that for an air-cooled aftercooler to function properly, a supply of cool ambient air must be ensured.

Figure 2
Horizontal Flow Air-Cooled Aftercooler

Figure 3
Vertical Flow Air-Cooled Aftercooler

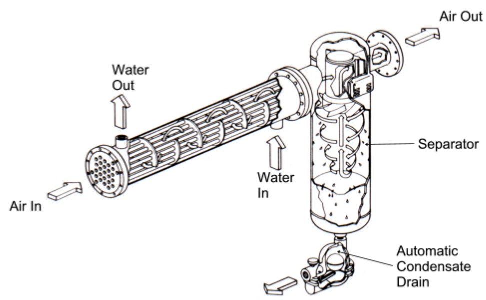

Figure 4
Water-Cooled Aftercooler

CENTRAL PLANT AIR DRYERS

Deliquescent Dryers

Deliquescent dryers employ chemicals with an affinity for moisture--- calcium chloride or sodium chloride, for example. These dryers however, are limited in dew point compatibility since the performance of the deliquescent chemical depends on operating temperature.

The most commonly used deliquescent dryer uses material in the form of pellets. This material turns to a liquid as the water vapor is absorbed and is drained off. The pellets added periodically. Inlet temperature should generally be 70^0F or lower and temperatures above 90^0F should be avoided. Dew point will depend on the inlet air temperature and pressure. A 100 PSIG system with 70^0F inlet temperature will provide a dew point of about 42^0F at operating pressure.

Although deliquescent dryers offer the advantage of lower initial capital costs, the deliquescent chemical is consumed during the drying operation and must be replaced on a periodic but ongoing basis.

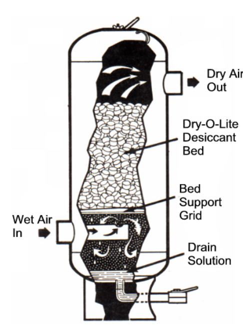

Figure 5
Deliquescent Dryer

Refrigerated Dryers

Refrigerated compressed air dryers are the most used type of dryer in manufacturing plant and auto body repair applications.

These dryers employ the simplest and most reliable method of removing moisture from compressed air – chilling the air to condense entrained water vapor, which produces dew points of +35^{0}F. Where pressure dew point requirements are above the freezing temperature of water, refrigerated air dryers are the most economical choice because of low initial cost as well as low maintenance and operating costs. Very little operator attention is required.

Generally refrigerated dryers use two heat exchangers in series to condense moisture and reheat the outlet air. Most refrigerated dryers pre-cool the incoming air before it reaches the refrigeration circuit. Pre-cooling reduces the load on the chiller so that smaller, and therefore less expensive, heat exchangers and refrigerant compressors may be used. The pre-cooling arrangement is usually an air-to-air heat exchanger, which uses outgoing cold air to cool the inlet air. Since this arrangement requires cold air to make cold compressed air, there is a delay in reaching the desired dew point on dryer start up.

A moisture separator is incorporated with the dryer to remove the condensed moisture.

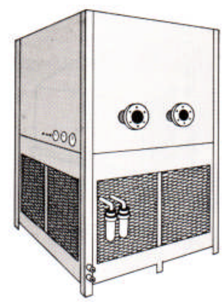

Figure 6
Refrigerated Air Dryer

Regenerative Dryers

Twin tower regenerative dryers work by Adsorbing moisture on a solid desiccant (drying material) such as activated alumina, silica gel or molecular sieve. The two towers operate alternately; compressed air to be dried is flowing through the desiccant in one tower while the desiccant in the other tower is being dried (or regenerated). The saturated desiccant bed is regenerated by a purge of dry air from the operating tower, or sometimes by suing supplemental heaters. Regenerative units supply the lowest dew point, usually –40^o F and, if required, as low as –100^o F. pressure dew point (down to 1 ppm moisture content). Regenerative dryers are often specified to protect instrumentation and control systems, laboratory equipment or moisture-sensitive process materials. The can also protect against freeze-ups in outdoor lines in the most severe weather conditions.

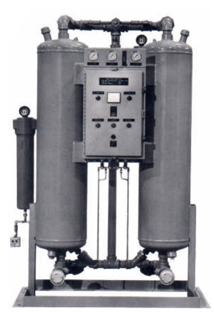

Figure 7
Heatless Regenerative Dryer

POINT-OF-USE DRYERS

Replaceable Cartridge Point of Use Dryers

These single tower dryers utilize replaceable cartridges which hold either clay, activated alumina or molecular sieve desiccant and are designed primarily for “point of use” applications, or to supplement an existing plant air dryer if a lower dew point is required in one specific are of the plant.

Water vapor is drawn out as it passes through the chemical.

Cartridge dryers produce an initial low dew point, however, the dew point gradually increases with time as the desiccant approaches saturation.

Because desiccant, which has been coated with oil, will have a reduced efficiency, these dryers should be used in conjunction with a good quality coalescing filter fitted with an automatic drain.

Since there are no moving parts, maintenance is minimal, requiring only periodical changing of the desiccant cartridge.

Figure 8
Replaceable Cartridge Dryer

- Clay Desiccant Cartridge Dryers

  Effective for both water and oil removal, a general-purpose desiccant, which can be used in any system. It produces initial pressure dew point of 20 to 25^{0}F. Life expectancy is up to three months depending on humidity, flow rate and frequency of operation.

- Clay Desiccant with Activated Carbon Cartridge Dryers

  A layer of activated carbon following the clay desiccant produces slightly lower initial dew point. It provides better removal of noxious gases and oil aerosols. It is to be used where a high degree of purification is required.

- Activated Alumina Cartridge Dryers

  Activated alumina dryers offer a relatively inexpensive cartridge with a high absorption capacity per unit weight, used primarily for removal of water vapor.

- Molecular Sieve Cartridge Dryers

  Molecular sieve is a highly porous material, which produces exceptionally low dew point – as much as a 80^{0}F initial pressure dew point depression. The desiccant also lasts longer than clay desiccants.

Membrane Dryers

A membrane type dryer consists of a bundle of hollow fibers mounted in a small-pressurized vessel or tube. These hollow fibers are composed of a selective barrier or membrane, which is specifically designed to attract water vapor. This means that the water vapor on the inside of the hollow fibres is absorbed and is then diffused through the very thin selective layer until the water vapour molecules have reached the outside of the membrane.

Depending on the operational parameters, the water vapor is removed selectively from the compressed air so that the compressed air on the outlet of the membrane dryer shows only little residual water vapor. The dryer functions because of the partial pressure difference between the inside and the outside of the hollow membrane fibers.

In practice, this means: the higher the pressure in the compressed air system, the better the operation of the membrane dryer.

In order to desorb the water vapor from the outside of the membrane, part of the air flow is taken from the dried compressed air, expanded to atmospheric pressure and used to flush away the moisture. In order to ensure a reasonable membrane life, it is critical that a high quality coalescing filter be installed before the dryer.

Figure 9
Membrane Dryers

Quantity of Water Entering System Per Day Per 100 SCFM in U.S. Gallons

AMBIENT TEMPERATURE	% HUMIDITY								
Degree F.	C	20	30	40	50	60	70	80	90
120	48.9	18.6	27.9	37.2	46.5	55.8	65.1	74.4	83.7
110	43.3	14.1	21.0	27.9	35.1	42.0	48.9	55.8	63.0
100	37.8	10.5	15.6	20.7	26.1	31.2	36.6	41.7	46.8
90	32.2	7.8	11.4	15.3	19.2	23.1	26.7	30.6	34.5
80	26.7	5.7	8.4	11.1	13.8	16.8	19.5	22.2	24.9
70	21.1	3.9	6.0	7.8	9.9	12.0	13.8	15.9	18.0
60	15.6	2.7	4.2	5.7	6.9	8.4	9.9	11.1	12.6
50	10.0	2.1	3.0	3.9	4.8	6.0	6.9	7.8	8.7
40	4.4	1.2	2.1	2.7	3.3	3.9	4.8	5.4	6.0
30	-1.1	.9	1.2	1.8	2.1	2.7	3.0	3.6	3.9
20	-6.7	.6	.9	1.2	1.5	1.7	1.9	2.1	2.4
10	-12.2	.3	.5	.7	.8	1.0	1.2	1.4	1.5

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