Dew-point measurements in compressed air

In industrial applications across the globe, compressed air supplies are a necessity. In Europe alone, it is estimated 10 percent of all industrial electricity consumed is used to produce compressed air. Compressed air is so vital to industry that it is often referred to as the fourth utility.

The applications of compressed air are almost limitless:

- Powering industrial air tools
- Breathing air for divers
- Drying of plastics and other finished goods
- Cleaning where water or solvents cannot be used
- Pneumatics – actuating valves and other mechanical components
- Food manufacture
- Powering medical or dental tools as a power source that produces no EMI
- Paint spraying
- Pressure testing
- and many more...

Compressed air can also be used as a safe alternative power source in hazardous locations where there is a risk of fire or explosion, such as mines and oil rigs.

Moisture in compressed air

When warm compressed air leaves the compressor, it contains a high level of water vapour. As the air travels through the compressed air distribution network it cools, and the water vapour will condense on any cold surfaces it comes into contact with. The condensation can form in fittings and fixtures along the distribution pathway, or inside tools, equipment and machinery once the compressed air reaches its destination.

A number of problems are caused by excessive moisture in a compressed air system:

- Condensation forming inside the distribution network will corrode pipework and fittings, reducing the smoothness of the inside surfaces, leading to pressure loss over time.

- Condensation can wash away the lubricant inside air tools, and rust, scale and other dirt that is carried along with the water droplets can foul up tools, ultimately leading to shorter lifetimes or unexpected failures.

- Oil from the compressor that has entered the distribution network can be particularly nasty when it mixes with moisture, forming an acidic emulsified paste that is harmful to many industrial materials.

- High levels of water vapour in medical or breathing gases make it uncomfortable to breathe and promote the growth of bacteria.

- Some countries impose regulations on certain industries and applications (medical, breathing air, nuclear) that outline a maximum amount of moisture permitted in compressed air.

To avoid condensation, the compressed air must be dried to a point where its dew point is lower than the temperature of the coldest surface that the compressed air could come into contact with at any point in the distribution network.

Removing moisture from compressed air systems

Aftercooler

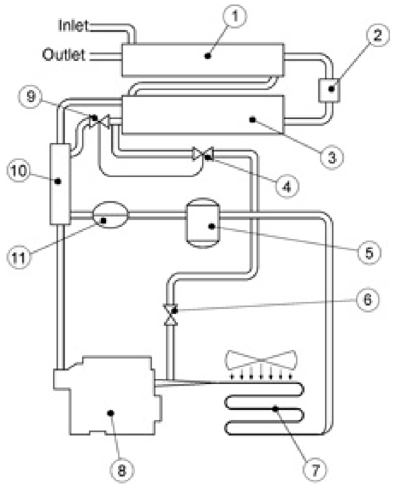
An aftercooler is an inexpensive solution to remove bulk moisture from the warm air leaving the compressor. It simply consists of an air or water cooled heat exchanger.

When the temperature of the compressed air is cooled below its dew point, moisture condenses out as liquid water which can then be separated from the compressed air stream and drained from the system. An aftercooler is often combined with another type of dryer.

Refrigerant dryers

Refrigerant dryers work on the same principle as an aftercooler, but cool the air further using a refrigeration system.

- Incoming air is pre-cooled by the cold air leaving the dryer in the air-to-air heat exchanger. This pre-cooled air also warms the outgoing air to prevent condensation forming on the pipework.
- The incoming air then passes over the cold section of the refrigeration coils, where the water condenses and is drained away.
- The temperature in the heat exchanger is closely controlled close to just above 0°C, to prevent ice forming on the surfaces of the cooling coils, which reduces the performance of the dryer.
- Due to the mode of operation refrigeration dryers have a specification in terms of dew point at system pressure of +2 or 3 °C. This can be converted to –25°C dew point at atmospheric pressure depending on system pressure.



1. Air to air heat exchanger
2. Separator
3. Air to refrigerant heat exchanger
4. Hot gas bypass valve
5. Liquid receiving tank
6. Hand shut-off valve
7. Air-cooled condenser
8. Refrigerant compressor
9. Expansion valve
10. Suction line heat exchanger
11. Filter

Dew point measurement for improved reliability

Refrigerant dryers are often fitted with a temperature sensor, which is thought to be comparable to measuring the dew point of the compressed air output. There are two main reasons why the temperature may not be indicative of the true dew point:

- In the case of high flow rates, the entire mass of air passing through the system is not cooled to the heat exchanger temperature, making temperature measurement misleading.
- Failed, blocked or faulty drain valves can lead to improper removal of water, leaving a fine mist in the compressed air output. Even when the drain system has become overloaded a steady flow of condensate may still be visible, meaning this fault may be overlooked.

Desiccant dryers

The most effective type of dryer is the twin-column desiccant dryer, which uses two cylinders filled with a moisture adsorbent. The active cylinder is fed with wet supply air from the compressor, removing moisture and producing a constant supply of dry compressed air. A small proportion of this dry air is used to regenerate the second, offline, cylinder.

These dryers are divided into two types: heated regeneration and heatless regeneration.

Heatless or Pressure Swing Dryers

These dryers typically use activated alumina or molecular sieve type desiccant as their drying media, and are capable of supplying dry compressed air with dew points as low as -50 and -90°C respectively. They are able to function because of the partial pressure gradient of the adsorbent, resulting in the deposition of the moisture from the wet air onto the large surface area of the porous adsorbent material.

A small proportion of the dry air from the active column is supplied back into the regenerating column to help with desorption of moisture from the saturated desiccant. Using a pre-set cycle timer, the role of the columns is switched; the 'dwell' time of each cycle is set depending on the columns' adsorbent capacity. When the columns switch roles, the rapid pressure drop in the active column also helps release adsorbed moisture.

Heat Regenerative Dryers

This type of dryer has a general component layout which is similar to that of the heatless regeneration version. However, in addition to a flow of already dried air, regeneration is achieved either with a heating element in direct contact with the adsorbent bed or by heating the air flowing into the column that is regenerating.

Hot air can transport a larger quantity of water vapour, resulting in faster desorption of moisture in the column that is regenerating than with a dry air flow alone. As a result, a much smaller quantity of dry air is required for regeneration, making the dryer more efficient.

In addition to the surface area, it is also possible to use the internal volume of the adsorbent. This significantly improves the moisture capacity of each column. When the adsorbent capacity and time of each column is known, the dwell times can be increased to make the optimum use of the capacity available. Moreover, by applying heat it is possible to fully regenerate the absorbent in this time.

Dew-point Dependant Switching (DDS)

Traditional regenerative dryers use a timer to determine when to switch roles of the drying and regenerating columns. The time between switch-over can vary from several minutes to several hours and is based on the minimum time it takes to regenerate a saturated column.

However, the rate at which the drying column becomes saturated is influenced by various factors including amount of air being consumed, the dryer input pressure, the temperature of the environment, and the humidity of the air used to feed the compressor. If the load on the dryer is low, then the drying column can still have the potential to continue drying the air at the time of switching and therefore this potential is wasted.

More sophisticated DDS dryers use a moisture sensor to determine the dew point of the active, drying column and only switch-over when this column adsorbed the maximum possible amount of moisture.

With DDS systems the regeneration of the inactive column is still based on time, but once the pre-determined regeneration time has elapsed, purge air is switched off completely (as are the heaters in heat regenerative dryers). When demand is low, the active, drying column is in operation for much longer, resulting in a large saving in purge air and heating costs.