Dewpoint in Compressed Air

Frequently asked questions:

1. What is dewpoint?
2. What is the difference between dewpoint and "pressure dewpoint?"
3. What is the effect of pressure on dewpoint?
4. Why is knowledge of dewpoint in compressed air important?
5. What is the typical range of dewpoint temperatures to be found in compressed air?
6. What are the standards for quality of compressed air?
7. How is dewpoint in compressed air reliably measured?
8. What are the telltale signs of a malfunctioning dewpoint sensor?
9. How often should a dewpoint sensor be checked or calibrated?

Vaisala DRYCAP® Hand-held Dewpoint Meter DM70

1. What is dewpoint?

Dewpoint temperature is a measure of how much water vapor there is in a gas. Water has the property of being able to exist as a liquid, solid, or gas under a wide range of conditions. To understand the behavior of water vapor, it is first useful to consider the general behavior of gases.

In any mixture of gases, the total pressure of the gas is the sum of the partial pressures of the component gases. This is Dalton's law and it is represented as follows:

$$P_{total} = P_1 + P_2 + P_3 \ldots$$

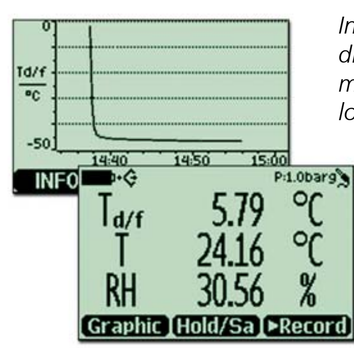
The quantity of any gas in a mixture can be expressed as a pressure. The major components of air are nitrogen, oxygen, and water vapor, so total atmospheric pressure is composed of the partial pressures of these three gases. While nitrogen and oxygen exist in stable concentrations, the concentration of water vapor is highly variable and must be measured to be determined.

The maximum partial pressure of water vapor is strictly a function of temperature. For example, at 60 °F (20 °C), the maximum partial pressure of water vapor is 23.3 millibars (mb). The value of 23.3 mb is said to be the "saturation vapor pressure" at 60 °F (20 °C). In a 60 °F (20 °C), "saturated" environment, the addition of more water vapor results in the formation of condensation. This condensation phenomenon can be exploited to measure water vapor content. Gas of unknown water vapor concentration is passed over a temperature-controlled surface. The surface is cooled until condensation forms. The temperature at which condensation forms is called the "dewpoint temperature." Because there is a unique correlation between temperature and saturation vapor pressure (remember, the maximum partial pressure of water vapor, also known as saturation vapor pressure, is strictly a function of temperature), measuring the dewpoint temperature of a gas is a direct measurement of the partial pressure of water vapor. Knowing the dewpoint temperature, the corresponding saturation vapor pressure can be calculated or looked up. The following table shows some values for temperature and the corresponding saturation vapor pressure:

Temperature °F (° C)	Saturation vapor pressure (mb)
68 (20)	23.3
32 (0)	6.1
14 (-10)	2.8
-4 (-20)	1.3
-40 (-40)	0.2

2. What is the difference between dewpoint and "pressure dewpoint?"

The term "pressure dewpoint" is encountered when measuring the dewpoint temperature of gases at pressures higher than atmospheric pressure. It refers to the dewpoint temperature of a gas under pressure. This is important because changing the pressure of a gas changes the dewpoint temperature of the gas.



Instruments with graphical displays are useful for monitoring dewpoint over a longer period of time.

3. What is the effect of pressure on dewpoint?

Increasing the pressure of a gas increases the dewpoint temperature of the gas. Consider an example of air at atmospheric pressure of 1013.3 mb with a dewpoint temperature of 14 °F (-10 °C). From the table above, the partial pressure of water vapor (designated by the symbol "*e*") is 2.8 mb. If this air is compressed and the total pressure is doubled to 2026.6 mb, then according to Dalton's law, the partial pressure of water vapor, *e*, is also doubled to the value of 5.6 mb. The dewpoint temperature corresponding to 5.6 mb is approximately 30 °F (-1 °C,) so it is clear that increasing the pressure of the air has also increased the dewpoint temperature of the air. Conversely, expanding a compressed gas to atmospheric pressure decreases the partial pressures of all of the component gases, including water vapor, and therefore decreases the dewpoint temperature of the gas. The relationship of total pressure to the partial pressure of water vapor, *e*, can be expressed as follows:

$$P_1/P_2 = e_1/e_2$$

By converting dewpoint temperature to the corresponding saturation vapor pressure, it is easy to calculate the effect of changing total pressure on the saturation vapor pressure. The new saturation vapor pressure value can then be converted back to the corresponding dewpoint temperature. These calculations can be done manually using tables, or performed by various kinds of software.

A variety of sample cell hardware, including quick disconnects, cooling coil and welded compression fitting, makes it easy to install a dewpoint sensor in any process.

4. Why is knowledge of dewpoint in compressed air important?

The importance of dewpoint temperature in compressed air depends on the intended use of the air. In many cases dewpoint is not critical (portable compressors for pneumatic tools, gas station tire filling systems, etc.). In some cases, dewpoint is important only because the pipes that carry the air are exposed to freezing temperatures, where a high dewpoint could result in freezing and blockage of the pipes. In many modern factories, compressed air is used to operate a variety of equipment, some of which may malfunction if condensation forms on internal parts. Certain water sensitive processes (e.g. paint spraying) that require compressed air may have specific dryness specifications. Finally, medical and pharmaceutical processes may treat water vapor and other gases as contaminants, requiring a very high level of purity.

5. What is the typical range of dewpoint temperatures to be found in compressed air?

Dewpoint temperatures in compressed air range from ambient down to -112 °F (–80 °C), sometimes lower in special cases. Compressor systems without air drying capability tend to produce compressed air that is saturated at ambient temperature. Systems with refrigerant dryers pass the compressed air through some sort of cooled heat exchanger, causing water to condense out of the air stream. These systems typically produce air with a dewpoint no lower than 23 °F (5 °C). Desiccant drying systems absorb water vapor from the air stream and can produce air with a dewpoint of -40 °F (–40 °C) and drier if required.

6. What are the standards for the quality of compressed air?

ISO8573.1 is an international standard that specifies the quality of compressed air. The standard defines limits for three categories of air quality:

- Maximum particle size for any remaining particles
- Maximum allowable dewpoint temperature
- Maximum remaining oil content

Each category is given a quality class number between 1 and 6 according to the reference values shown in the table below. As an example, a system that conforms to ISO8573.1 and is rated for class 1.1.1 will provide air with a dewpoint no higher than -94 °F (–70 °C). All remaining particles in the air will be 0.1 um or smaller, and the maximum oil content will be 0.01 mg/m^3. There are other standards for compressed air quality, such as ANSI/ISA-7.0.01-1996 for instrument air.

ANSI/ISA-7.0.01-1996 for instrument air.

Quality Class	Particle Size (um)	Dewpoint ° C	Dewoint ° F	Oil Content (mg/m^3)
1	0.1	-70	-94	0.01
2	1	-40	-40	0.1
3	5	-20	-4	1
4	15	3	37	5
5	40	7	45	25
6	-	10	50	-

7. How is dewpoint in compressed air reliably measured?

Some principles of dewpoint measurement apply to all types of instruments, regardless of manufacturer:

- Select an instrument with the correct measuring range:
  Some instruments are suitable for measuring high dewpoints, but not low dewpoints. Similarly, some instruments are suitable for very low dewpoints but are compromised when exposed to high dewpoints.

- Understand the pressure characteristics of the dewpoint instrument:
  Some instruments are not suitable for use at process pressure. They can be installed to measure compressed air after it is expanded to atmospheric pressure, but the measured dewpoint value will have to be corrected if pressure dewpoint is the desired measurement parameter.

- Install the sensor correctly:
Follow instructions from the manufacturer. Do not install dewpoint sensors at the end of stubs or other “dead end” pieces of pipe where there is no airflow.

Vaisala manufactures a family of instruments that are ideal for measuring dewpoint temperature in compressed air. DRYCAP® sensor technology provides fast dewpoint measurements from ambient temperature down to -76 °F (−60 °C) with an accuracy of ±3.6 °F (±2 °C) over the entire range. In addition to the general principles given above, consider the following when selecting and installing a Vaisala dewpoint instrument:

A. The best installation for a dewpoint sensor isolates the sensor from the compressed air line. This is accomplished by installing the sensor in a “sample cell” and connecting the cell to a “T” in the compressed air line at the point of interest. A small amount of compressed air is then bled past the sensor. The cell should be made of stainless steel and connected to the “T” with tubing (1/4” or 6mm). It is useful to install an isolation valve between the cell and the air line. This enables easy installation and removal of the sensor.

B. A flow-regulating device is necessary to control to airflow past the sensor. The desired flow rate is only 1 slpm (2 scfh). The regulating device can be a leak screw or a valve. To measure pressure dewpoint, the regulating device is installed downstream of the sensor, so that when the isolation valve is opened, the sensor is at the process pressure. To measure dewpoint at atmospheric pressure, the regulating device should be installed upstream of the dewpoint sensor.

C. Do not exceed the recommended flow rate. When measuring pressure dewpoint, an excessive flow rate will create a local pressure drop at the sensor. Because dewpoint temperature is pressure sensitive, this will create an error in the measurement.

D. The best tubing material is stainless steel(SS). Non-metallic tubing can absorb and desorb water vapor, creating a lag in measurement response. If SS tubing is not available, consider using PTFE or other materials that do not absorb water. Avoid the use of clear plastic tubing or yellow rubber tubing.

E. It is possible to reduce installation costs for permanent dewpoint instruments by installing the sensor directly in the compressed air line. In these cases it is important to choose a location where the sensor has adequate airflow and where the temperature of the compressed air is at or near ambient

The DSS70A fully integrated sampling system expands the versatility of a dewpoint sensor, enabling measurement of other plant processes that might not be under positive pressure.

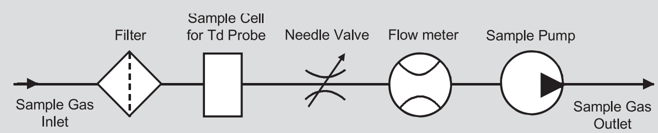
8. What are the telltale signs of a malfunctioning dewpoint sensor?

- An instrument that displays one value all of the time, as if the output or display were locked.
- An instrument that is “bottomed out,” always reading its lowest possible value.
- An instrument that is erratic, changing rapidly or randomly over a wide range of values.
- An instrument that displays impossibly dry or wet dewpoint values.

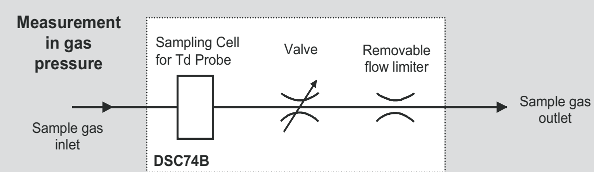
9. How often should a dewpoint sensor be checked or calibrated?

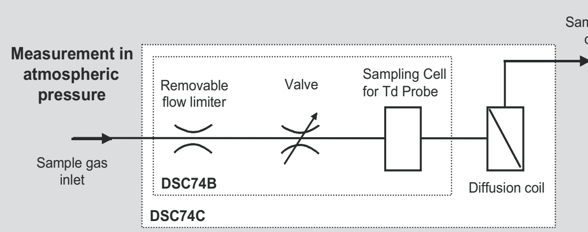
It is best to follow the manufacturer’s recommendation. Vaisala suggests a one or two year calibration interval, depending on the instrument. Sometimes a simple field check against a calibrated portable instrument is sufficient to verify correct operation of other instruments. Vaisala provides detailed calibration information in the User’s Manual that is shipped with each instrument. Any time that you have doubts about the performance of your dewpoint instruments, it is wise to check their calibration.

DSS70A Sampling System and DSC74B/C Sampling Cells



The DSS70A sampling system includes a filter to clean the dirty sample gas and a needle valve to control the sample flow rate with the flow meter. A sample pump is used to generate a sample flow from processes at ambient pressure.





The DSC74B sampling cell enables the measurement of the sampled gas either in gas pressure up to 10 bar or in atmospheric pressure depending on the gas inlet and outlet. The DSC74C is like the DSC74B but with an additional coil to avoid back diffusion, the effect of surrounding moisture, in dewpoint measurements in atmospheric pressure.