HOW'S THE WEATHER IN YOUR PIPES?

By Ron Marshall for the Compressed Air Challenge®

What are the conditions inside your pipes, is it cloudy and hot with showers or cool and dry? Could there be snow and blowing snow and excessive icing conditions? Are there smog and dust storm conditions or is the air as fresh as a mountain breeze. All these conditions are commonly experienced inside compressed air systems. What you get is determined by your selection of system equipment, ambient conditions and how well your system is maintained. Compressed Air Challenge's Fundamentals and Advanced Seminar material, and our Best Practices Manual contain a wealth of background material about air quality and dryers that could make you a good weather maker for the air inside your pipes. The following is a sample of the information provided.

Why Does Compressed Air Need Drying?

All atmospheric air contains some water vapor which will begin to condense into liquid water when the air in a compressed air system cools to the saturation point, i.e., the point where it can hold no more water vapor. The temperature at which this happens is known as the dew point. This dew point is a key factor in determining how much drying is needed.

Condensation in the compressed air system would occur at the intake air saturation temperature (the dew point of the ambient air) if the temperature remained constant as air was compressed. However, since there is a rise in temperature during actual compression, condensation generally does not occur within the compression elements. But later, as compressed air is discharged and cooled in an after cooler, condensation begins to occur as the temperature drops. The condensed moisture must be removed by an efficient separator and trap.

The air leaving the after cooler is normally is normally 100% saturated at the after cooler discharge temperature. Thus the dew point

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of the air within the pipes is about the same as the cooling air temperature plus the cold temperature differential of the after cooler. As the hotter air cools to ambient some moisture drops out of the air.

For many years, problems from moisture in air lines were tolerated. To prevent freezing, alcohol was injected into the lines and electric heaters were used during cold periods. Filters were used to separate moisture and other contaminants, but did not completely solve the problem. The increased use of compressed air and the development of many new and more sophisticated devices and controls have accelerated the need for clean dry air. Hence drying technologies have advanced, and dryers have come into general use. Dryers are used for the following reasons:

- Moisture in compressed air used in manufacturing plants causes problems in the operation of pneumatic air systems, solenoid valves, and air motors by leading to rust and increased wear of moving parts as it washes away lubrication. Moisture also adversely affects the color, adherence, and finish of paint applied by compressed air.
- Moisture causes problems in process industries, where many operations are dependent upon the proper functioning of pneumatic controls. The malfunctioning of these controls due to rust, scale, and clogged orifices can result in damage to product and costly shutdowns. Additionally, the freezing of moisture in control lines in cold weather commonly causes faulty operation of controls.
- Corrosion of air or gas operated instruments from moisture can give false readings, interrupting or shutting down plant processes.

Measuring Moisture Content

Obviously there are times when it is desirable to know, with varying degrees of accuracy, the moisture content of the compressed air. Methods are available which will give you readings, which vary from approximations to precise measurements:

- Moisture Indicating Desiccants
- Dew Point Cup
- Refrigerant Evaporation
- Fog Chamber
- Infrared Analyzer
- Capacitance
- Hygroscopic Cells
- Frequency Oscillator

By far the most common method these days is the Capacitance Cell method. A good accurate instrument that can be used to constantly monitor dew points and ensure you are getting top quality compressed air and to guard against unexpected failure of drying equipment. These cells are also used with dryer controls to cut back the purge flow of compressed air dryers.

Specifying a Compressed Air Dryer

The air dryer with certain auxiliary equipment becomes a system, which is an important component of the whole plant compressed air system. Various components comprising the dryer subsystem should be selected on the basis of the overall requirements and the relationship of the components to each other. The selection of the drying equipment can significantly affect the cost of compressed air in your facility. Good management of the costs means that you dry your air only to the level required by your plant production equipment or ambient conditions.

There are just three main factors to analyze in selecting the appropriate dryer (including size) to provide your required performance — dew point, operating pressure and inlet temperature.

Dew point — Refrigerant dryers provide a pressure dew point of 35 °F or 50 °F at operating pressure based on saturated inlet air temperature of 100 °F. Regenerative desiccant dryers generally provide a pressure dew point

Moisture Carrying Capacity of Air

The maximum water vapor the air can hold depends upon the temperature and pressure. The amount of vapor the air actually does contain — relative to the most it can contain is relative humidity (the ratio of the quantity of water vapor present to the quantity present at saturation at the same temperature).

Dew Point

The temperature at which water vapor in the air starts to condense or change from vapor to a liquid or a solid state. (Dew points may be expressed at an operating pressure or at atmospheric pressure. Operating pressure should be specified when using pressure dew point. The relationship between pressure and atmosphere dew point is shown on Chart No. 3 in the appendix.

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of minus 40 °F or lower, at operating pressure and 100 °F saturated inlet air temperature.

Deliquescent dryers are more sensitive to the saturated inlet temperature and, based upon a saturated inlet air temperature of 100 °F, provide a dew point from 64 °F to 80 °F at operating pressure.

Operating Pressure — At higher pressures, saturated air contains less moisture per standard cubic foot than lower pressure saturated air. Drying air at the highest pressure consistent with the plant design will result in the most economical dryer operation. Chart 1 shows the relationship between operating pressure and water content. Taking air at 100 psig as the normal pressure, a subsequent decrease in pressure results in a substantial increase in the water to be removed. At higher pressures the water content curve tends to increase at a slower rate.

Inlet Temperature — The temperature of air entering the dryer is usually close to the temperature at which it leaves the aftercooler. Saturated air at 100 °F saturated contains almost twice the amount of moisture of saturated air at 80 °F. For every 20 °F increase in the temperature of saturated air, there is an approximate doubling of the moisture content. Thus it is desirable to operate the dryer at the lowest feasible inlet temperature.

Selecting The Right Dryer

Before looking at the several types of dryers available, we need to look at what to consider in deciding which dryer is best for the specific requirements.

Know the Specific Uses of the Compressed Air — The selection of an air dryer is done best by the professional who knows or learns the particular end-uses, the amount of moisture which each use can tolerate, and the amount of moisture which needs to be removed to achieve this level. Air which may be considered dry for one application may not be dry enough for another. Dryness is relative. Even the desert has moisture. There is always some moisture present in a compressed air system regardless of the degree of drying. Different types of dryers, therefore, are available with varying degrees of pressure dew point ability. To specify a dew point lower than required for an application is not good engineering practice. (Naming a pressure dew point is how to state the degree of dryness wanted.) It may result in more costly equipment and greater operating expense.

Know the Temperatures

To determine whether or not the compressed air will remain sufficiently dry, we must know the end-use of the air and the temperature at which it must work. In an industrial plant where the ambient temperature is in the range of 70 °F or higher, a dryer capable of delivering a pressure dew point 20 °F lower than ambient, or 50 °F, may be quite satisfactory. Summer temperatures do not require a very low dew point whereas winter temperatures may dictate a much lower dew point. In winter, the cooling water temperature usually is lower than in summer, resulting in a variation of the air temperature to the dryer. This will affect the size of the dryer needed, since the same

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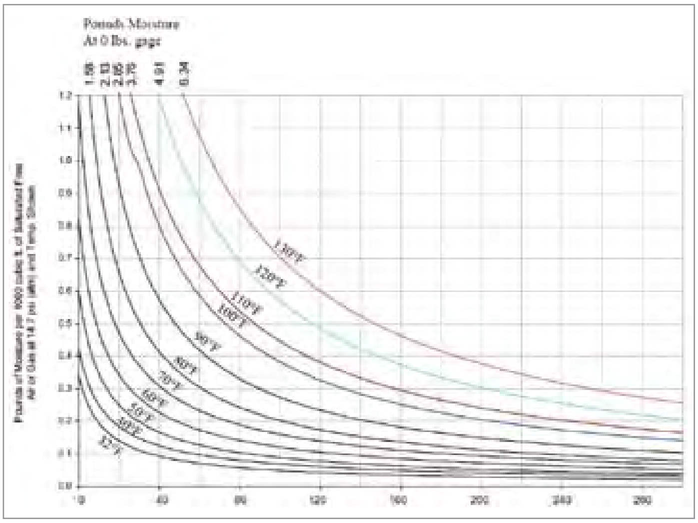

Moisture content in saturated air with varying pressure (PSI).

dryer must work in both summer and winter temperatures and relative humidities. For example, many chemical processing plants, refineries, and power plants distribute instrument and plant air throughout the facility with lines and equipment located outside the buildings. In such plants two different temperature conditions exist at the same time in the same system. Also, a dryer, which may be satisfactory for high daytime temperatures may not be satisfactory for lower nighttime temperatures. In areas where freezing temperatures are encountered, a lower pressure dew point may be required. In general, the dew point should be specified 20 °F lower than the lowest ambient temperature encountered in order to avoid potential condensation and freezing. To specify a winter dew point when only summer temperatures will be encountered, can result in over-sizing the equipment and increased initial and operating costs. For plant air and instrument air, primary considerations in specifying a dryer are condensation and freezing. In a system where a lot of internal pipe corrosion could occur, high humidity in the air stream should be avoided.

Know the Actual Performance — While many dryers have a standard rating of 100 °F saturated inlet air temperature and 100 psig operating pressure, it is important to check on the actual performance of the units obtained in actual plant operating conditions.

Know Each Use — In addition to plant and instrument air applications, there are many other uses requiring moisture removal to a low dew point. For example, railroad tank cars which carry liquid chlorine are often padded (charged) with compressed air to enable pneumatic unloading. Chlorine will combine with water vapor to form hydrochloric acid; therefore, the compressed air must have a minimum moisture content to prevent severe corrosion. Another example are droplets of moisture in wind tunnel air at high-testing velocities; these droplets may have the effect of machine gun bullets, tearing up the test models. Another example is where compressed air used for low temperature processing (for example, liquefaction of nitrogen or oxygen) can form ice on cooling coils, thus requiring defrosting. The lower the moisture content of the air, the longer the periods between defrosting shutdowns.

For these and similar temperature applications, compressed air must not only be free of liquid phase water but must also have a minimum content of vapor phase water. Usually specified for these requirements are dew points in the range of -80 °F to -100 °F at pressure.

Mind the Inlet Temperatures

Because, as mentioned earlier, the amount of water in the compressed air being processed by the dryer significantly increases as the temperature increases, high compressor discharge temperatures due to extreme ambient conditions or a problem with the compressor cooling system. When this happens the design capacity of the dryer will be exceeded allowing water to pass unprocessed into the downstream system causing contamination problems. To avoid these problems the dryer inlet temperatures should be continuously monitored. If problems exist some remedial measures may be required like compressor cooling system redesign, adding a wet storage receiver to help cool the air, or a secondary aftercooler with a separator.

Maintain Your Equipment

Often poor maintenance of condensate drains, cooling radiators, and filter elements can affect air dryer operation, even if the equipment requiring maintenance is not associated with the air dryer. Maintenance staff must ensure the condensate that is supposed to be drained before it gets to the dryer is removed. Cooling surfaces that are coated with dust or oil cannot remove the heat from the air before it gets to the dryer. Filters that are clogged or have failed inside and are passing water through due to element failure can significantly affect dryer performance. BP

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