

# Fluid Power Design Data Sheet



## REVISED SHEET 45 - EVOLUTION DESIGN DATA FILE

### HOW TO SOLVE YOUR AIR LINE WATER PROBLEM

Certain applications, like those pictured below and others, will not tolerate any water whatsoever condensed out of the air line. One of several methods may be used to eliminate the water problem. To better understand the solutions proposed here, the reasons for the presence of water in the air line should be understood.

#### TERMS DEFINED

All air, including both compressed air and free air, contains water in vapor form and sometimes in mist or fog form as well.

**Water Vapor.** This is water in gaseous form, which is dissolved in the air and is completely invisible. There is no filter, no matter how intricate, that can filter water vapor out of an air line. Vapor can only be removed by a dehumidifying process.

The maximum quantity of water that air can hold in vapor form depends on its pressure and temperature. Warm air will hold more water vapor than can colder air at the same pressure, and compressed air can hold more than free air at the same temperature.

**Relative Humidity.** The quantity of water vapor in the air compared to the maximum quantity that the same air can hold at the same temperature and pressure is defined as the relative humidity. A relative humidity of 40%, for example, indicates that the air is holding only 40% of the quantity of water vapor that it can hold at that pressure and temperature. Air at 100% relative humidity is said to be "saturated." Evaporation can take place into any air except that which is at 100% relative humidity. If either the pressure or the temperature of "saturated" air is reduced, even slightly, its capacity for holding water vapor is diminished, and the excess water vapor condenses, usually in the form of fog or mist.

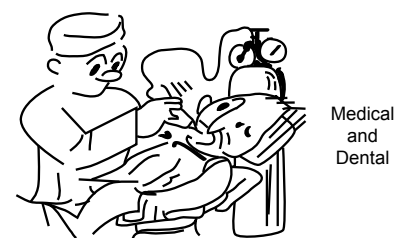
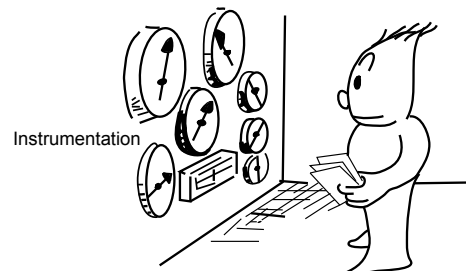
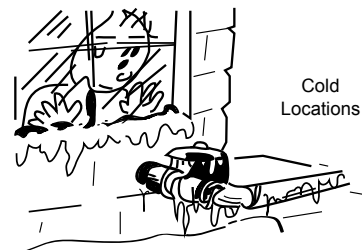
**Water Mist.** This is actually liquid water in such finely divided particles that it will remain suspended indefinitely in air. It is visible if present in appreciable quantities. A good air line filter can remove up to 98% of the water mist. Water mist is harmful in a compressed air system; water vapor is not. As long as water vapor remains in vapor form, it does no harm; in fact, it carries a part of the fluid power flowing through the system. It is only when it condenses into mist that it becomes harmful.

#### THE PROBLEM

Free air drawn into the compressor intake contains a moderate level of water vapor. As the air is compressed, the vapor concentration or the relative humidity increases in the same ratio as the compression ratio, resulting in the air delivered from the compressor is nearly always at saturation or 100% relative humidity. Excess water condenses during the compression process and the subsequent cooling process and collects in the bottom of the receiver tank where it can be regularly drained off. Air piped from the receiver tank through the air distribution system and through machines that operate from the air line is at saturation and will drop out water at any and every place in the system where its temperature or pressure drops, even slightly. Obviously, any condensation that appears in the line following a filter cannot be picked up by that filter.

#### THE SOLUTION

Since water vapor cannot be filtered out, the only solution to the water problem is to use some kind of dehumidifying process to remove enough of the vapor so any further drop in either pressure or temperature down the air line or in the machines which use the air will not cause water to drop out. It is neither necessary or desirable to remove all of the vapor because the vapor, if it remains a vapor, works just as effectively as compressed air in moving a cylinder. Removing more vapor than necessary wastes power.



## WATER REMOVAL METHODS

### COMPRESSOR AFTERCOOLER

During compression, the air may momentarily reach a very high temperature, up to 450°F. Of course, it cools rapidly as it is passed into a receiver (storage) tank. During this cooling process, it drops a great deal of water by condensation. This condensate can be drained off. The air in the receiver is now at saturation, and, at any later time, if it cools further, additional water will drop out.

Most large compressor systems use a water-cooled aftercooler between the compressor and the receiver tank. One key to water elimination is to cool the air passing through the aftercooler to less than room temperature or as low as possible. Air which has once been cooled to less than room temperature will usually not drop any more water after it has warmed back up to room temperature.

**Water Consumption of Aftercoolers.** The rule-of-thumb for water supply to an aftercooler is 1 GPM of water for every 25 HP of compressor capacity. This is based on 75°F inlet water, 120°F inlet air, 80°F outlet water, and 90°F outlet air. For conditions other than stated, more or less water may be required. The higher the air pressure, the more efficient its operation and the less water required.

**Best Compressor-Pressure.** On relatively small air systems, raising the cut-out pressure on the compressor, then dropping the pressure through a regulator, may reduce the relative humidity so no air dryer is needed.

The relative humidity of saturated air when its pressure is reduced through the regulator becomes less than 100%, and it may be dry enough so no additional dryer is needed, especially if it is allowed time to warm up to room temperature after it has expanded through the regulator. It can be discharged into a large volume storage tank before use so it will have time to reach room temperature.

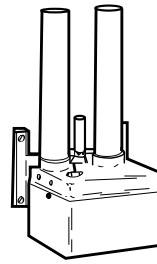
### AIR DRYERS

The two most common ways of reducing water vapor content of compressed air, on a large scale, are to condense it out with a refrigeration system or to absorb it with some kind of a dessicant system of which there are several.

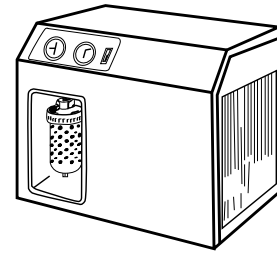
**Refrigeration-Type Air Dryers.** Inlet air is chilled to about 39°F to force it to drop part of its water vapor by condensation. At this temperature, it is at saturation or 100% relative humidity. Before being discharged, it is heated back up to room temperature and will be at some point below saturation. In subsequent usage, no more water will drop out unless the air is cooled to a temperature less than 39°F.

A conventional freon-type refrigeration system is employed. These dryers are manufactured with ratings from 1/6 to 10 HP. The 10 HP model has capacity to service up to 500 HP compressor capacity at normal shop air pressure.

**Dessicant-Type Twin Tower Heatless Dryer.** Two identical towers are filled with a dessicant similar to silica gel that will "adsorb" water without combining with it. The water is simply trapped and held. The dessicant can be purged by a flow of dry air at room temperature through it. After a timed interval, which may be from 3 to 5 minutes, the towers are switched so the first one can be dried while the second one is in service.



Twin Tower  
Air Dryer



Refrigeration  
Air Dryer

In the heatless version of the twin tower dryer, water is removed from the dessicant during the regeneration cycle by passing a small flow of dry air, tapped from the dry air flow from the opposite tower, through it. Water is picked up and vented to atmosphere. The towers are switched by two 3-way or one 4-way solenoid valve controlled with an electric timer. During regeneration, every cubic foot of compressed dry air, when allowed to expand about 7 times (from 100 PSI) to atmospheric pressure, can carry out 7 times as much water vapor as was carried in.

These dryers require no maintenance or replenishment of dessicant. No water drain is required. They consume only about 50 watts of electricity. They can produce very dry air, down to -75°F depending on the dessicant used. They can be shut down at night and on week ends and will immediately produce dry air when turned on. About 15% of the entering compressed air is consumed for regeneration.

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Currently, these dryers are available for air flows to 600 SCFM at 100 PSI. Larger models are no doubt available on special order.

**Dessicant-Type Twin Tower Heated Dryer.** These dryers are similar to the heatless type but use heat derived from electrical power to dry the dessicant. They deliver 100% of the inlet air to the output but require electrical power - the amount according to dryer size.

**Chemical Dessicant Dryer.** Many chemicals have a dessicant action; that is, the ability to chemically combine with water vapor, forming a solution. Incoming air is passed through a bed of chemical dessicant and the resulting solution of water and chemical is drained away. From time to time the dessicant bed must be serviced and additional dessicant added. Common dessicants are salt or urea.

This type dryer is capable of giving excellent results but requires very frequent and careful maintenance. They are little used today, having been replaced by other types. We no longer recommend them because of their high cost of maintenance (manpower and dessicant), the corrosive effect of dessicant that could enter the air stream, their sensitivity to high air temperature, and their relative inefficiency.