Humidification Of Gas Streams Using Liqui-Cel® Membrane Contactors

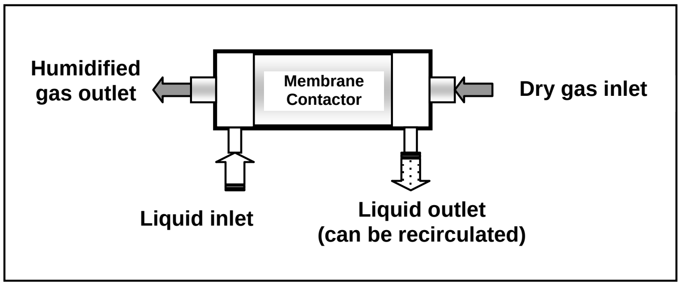
The process of humidification occurs when a gas stream is brought in contact with a liquid stream (typically water). Liquid evaporates at the gas-liquid interface and the liquid vapor humidifies the gas. Conventionally, Spray or Bubble columns have been used for humidification. However, Liqui-Cel® Membrane Contactors offer a more efficient method.

FEATURES	BENEFITS
The inter-phase contact area per unit device volume is very high	Equipment can be small in size, and hold up volumes are low
No flooding or loading limitation since the gas liquid interface is stable	Gas and liquid flow rates can be controlled independently
Operation is gravity-independent	Gas and liquid can flow horizontally or vertically.
Humidification can be done in-line at high gas pressures	Gas does not have to be re-pressurized after humidification

A membrane contactor is made from microporous hydrophobic hollow fiber membranes, which repel water and allow stable gas-liquid interface to form without dispersion. If the liquid is water or an aqueous solution the membrane pores remain gas-filled and the rate of humidification is controlled only by diffusion in the gas phase, which is very fast. If the membrane does not repel the liquid and the pores are filled by wicking action, membrane contactors will still work under appropriate process conditions. Humidification with a liquid other than water (e.g. an organic solvent) is therefore also possible.

Membrane contactors have several unique advantages over conventional columns or towers. The degree of humidification can be regulated by proper control of operating parameters and system design.

All these benefits, plus the fact that membrane contactors are available in a wide range of sizes, make them ideally suitable in this application. The typical schematic flow diagram of a membrane humidification system is shown in the Figure below.

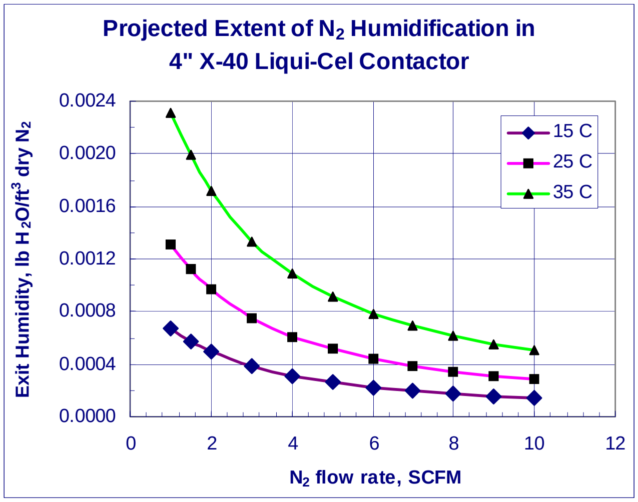


The humidity of a gas stream can be expressed in terms of relative humidity or absolute humidity. Relative humidity can be 0% (bone-dry gas) to 100% (completely saturated), and is the ratio of the 'partial pressure' of liquid vapor in the gas stream to the 'vapor pressure' of liquid at the prevailing temperature. The absolute humidity, on the other hand, is simply the ratio of the mass of liquid vapor in the gas phase to the mass of dry gas. Two different humidified gas streams can have identical relative humidity but widely different absolute humidity, depending on temperature, gas pressure and molecular weight of the gas.

The driving force for humidification is the liquid vapor pressure, which depends strongly on temperature. As the liquid evaporates, however, the latent heat of evaporation causes the local liquid surface temperature to drop, which in turn reduces the local vapor pressure and the rate of humidification. Heat and mass transfer processes are thus intimately coupled. Depending on how fast the bulk liquid moves inside the contactor, this 'evaporative cooling' effect may be significant. To minimize the effect of evaporative cooling it is recommended to continuously flow liquid through the contactor. Depending on the application, the liquid may be recirculated back to the contactor, in which case the system should be designed to maintain the water temperature.

Liqui-Cel® Membrane Contactors are available in a variety of sizes with a range of membrane area from 0.1 m^2 to 135 m^2. A membrane contactor has a shell side and a lumen side. It is possible to run liquid on shell side and gas on lumen side, or vice versa. However, from pressure-drop considerations it is generally preferred to have the gas flow through the shell side (lower pressure drop) for humidification applications.

The humidity of the gas leaving the membrane contactor depends on many factors. Primary process parameters are liquid and gas temperatures, liquid and gas flow rates, membrane area, and gas pressure. In general, as gas flow rate increases the effluent gas humidity decreases. Providing additional membrane area will increase humidity. The chart shown at right indicates the trend of absolute humidity with gas flow rate at various temperatures. The results illustrated are for humidification of gaseous nitrogen with water in a 4x28 Liqui-Cel® Membrane Contactor with approximately 13.3 m^2 of gas-liquid contact area (lumenside). The gas is assumed to be at atmospheric pressure and the evaporative cooling has been assumed to be insignificant.



Please contact your local Membrana representative if you have additional questions or you would like to discuss how these membranes can be incorporated into your system for humidification of gas.

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