Product migration of liquefied compressed gases in manifolded systems

One of the most common methods used to increase the withdrawal of gaseous phase product from liquefied compressed gas cylinders is to manifold several together. This method is seen as having advantages over other methods used to increase withdrawal rates, such as heating or withdrawing liquid phase product and running it through a vaporizer. Manifolding is looked at as being safer and less expensive. However, under certain conditions, product from one container can migrate to another, causing serious overfill conditions if that container's valve is closed. The vapor pressure of a liquefied compressed gas is directly related to the temperature of the liquid. A difference of just a few degrees in temperature between cylinders can cause the gas in the warmer cylinder to travel into the cooler cylinder and condense as the product in that cylinder equilibrates. This migration does not take place when the product is being used because the gas is being removed to the process. The migration is slow, so short time intervals at minor temperature differences are usually not a problem. The risk increases with the temperature differential between the cylinders and when the cylinders are stored for long periods of time, as on a product reserve bank.

Warning

Manifolding liquefied compressed gas cylinders together without good engineering practices to prevent product migration of one cylinder's contents into another cylinder may result in:

1. Container rupture
2. Major property damage
3. Serious injury or death
4. Noncompliance with local, national, or international shipping and fire/occupancy regulations.

If enough product migrates into a container, a dangerous overfill condition can be created. The overfilled cylinder can be at risk if the cylinder valve is closed. The amount of liquefied gas permitted in a cylinder is determined by transportation regulations to prevent the cylinder from becoming liquid-full under normal ambient conditions. A vapor space must be left in the container so when the cylinder encounters a warmer ambient condition, the liquid has space where it can expand. If the closed cylinder becomes liquid-full and the liquid starts to warm and expand, tremendous hydrostatic pressure can be generated and the container may fail.

Product migration is dependent upon time and temperature differential. These parameters are most hazardous in the use of reserve cylinder banks. Air Products recommends that reserve banks be limited to one cylinder wherever possible. Depending on the use rate, a one-cylinder reserve can provide adequate product to the process while the primary bank is changed. The system can then be changed back to the primary bank or, if the one-cylinder reserve will not last longer than 24 hours, the reserve can be left active until the system changes over. This will eliminate the potential for long-term storage of manifolded open cylinders. This also provides a measure of safety in that it minimizes the amount of product available to escape in the event of a system failure. If this solution is not practical, other options are available. Whenever liquefied compressed gas cylinders are manifolded, they must be isolated from one

another with a positive flow prevention device (check valve) to prevent product migration between cylinders. However, this should only be used as backup protection, since they can malfunction. The manifold can be located in a temperature-controlled room or area where the temperature of all cylinders will remain the same. Also, as cylinders are replaced on one bank of the manifold, their temperatures should be verified to be as uniform as possible. This can be accomplished by storing all full cylinders for future use in the same environment and replacing all cylinders on one manifold bank at the same time. Scales can also be placed under the cylinders to detect product movement between cylinders. Automated scale systems can be used to initiate an alarm on increasing weight of one or more cylinders manifolded together. Finally, some liquefied compressed gas systems utilize external heat on the cylinders to provide increased product vapor pressure. Such external heating systems should be evaluated to ensure they provide even distribution of the heat on each manifold bank (i.e., avoid having one cylinder located nearer an external heating element than another cylinder). If individual cylinder heating jackets are used, the temperatures of each jacket should be monitored and alarmed on a temperature differential. Note that a cylinder should never be heated above 125°F (51.7°C).

Product migration can also lead to quality problems. In operations where microcontamination can create quality problems, product migration can lead to one or more cylinders going liquid dry. As gas is withdrawn from the cylinder, less volatile contaminants can concentrate in the liquid. When the last liquid vaporizes, it can release a burst of contaminants that may create quality problems in the process. Having scales under the individual cylinders can be used to alert the user that a specific cylinder is close to going liquid dry so the container can be closed, preventing a possible surge of contamination.

Tube trailers and ISO modules containing liquefied compressed gases are very susceptible to product migration by their very design. These are large units that are typically used outside in open areas. The upper tubes are exposed to direct sunlight while the lower tubes can be shaded. This can create a fairly large temperature differential. Tubes in the middle of lower rows are in turn shielded from air flow by the tubes on the outside, creating more opportunity for temperature differential between tubes. Air Products recommends that only one tube be opened at a time, but in some applications multiple tubes are required to provide a sufficient flow of product. When multiple tubes are required, we recommend that tubes in the same row be used to minimize the possibility of uneven cooling. However, this is not a guarantee of even cooling, especially for tubes in the lower rows, because shadows or other environmental conditions may influence tube temperatures. Since the only way to detect product migration is by weighing the individual containers, it is not possible to determine if and when migration has occurred in a tube trailer or ISO module. The only protection against hydrostatic overpressure is to avoid closing the tube valves and to use the product until the tubes' pressure is below the vapor pressure of the coldest tube for the specific product.

For more information concerning liquefied compressed gases, refer to Air Products' Safetygram #30, "Handling Liquefied Compressed Gas."

Emergency Response System

T 800-523-9374
(Continental U.S. and Puerto Rico)
T +1-610-481-7711 (other locations)
For regional ER telephone numbers, please refer to the local SDS 24 hours a day, 7 days a week for assistance involving Air Products and Chemicals, Inc. products

Technical Information Center

T 800-752-1597 (U.S.)
T +1-610-481-8565 (other locations)
Monday–Friday, 8:00 a.m.–5:00 p.m. EST
F 610-481-8690
gastech@airproducts.com

For more information, please contact us at:

Corporate Headquarters
Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195-1501

For regional contact information, refer to the local SDS or contact your local sales representative.

AIR PRODUCTS

tell me more
airproducts.com