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PURGING HIGH PURITY GAS DELIVERY SYSTEMS

Instructions

READ AND COMPLY WITH THESE INSTRUCTIONS BEFORE INSTALLING, OPERATING, OR SERVICING

INTRODUCTION

It is important to remove room air from all portions of a high purity gas piping system prior to process gas introduction. There are two reasons why this is required:

1. Any residual air reduces process gas purity. This is true for any process gas, whether hazardous or not.
2. Air contains oxygen and water vapor; some specialty gases react with oxygen, and the resulting reaction products can cause process contamination and manifold component failure. Other gases form highly corrosive products upon contact with water vapor, causing damage to the piping system. Equipment corrosion can also contaminate the process.

It is also necessary to remove process gas from any portion of the piping system before exposure to atmosphere, such as when changing gas cylinders or performing maintenance on the system. There are three reasons for this:

1. Many specialty gases are highly toxic and would present a severe health hazard to personnel.
2. Some gases are highly flammable or even pyrophoric and would pose the hazard of fire or explosion.
3. Other gases become highly corrosive on contact with water vapor present in air and could damage equipment and facilities.

METHODOLOGY

Removal of the undesired gas, either air or process gas, is known as ***purging***. Purging is accomplished by either ***evacuation*** of the undesired gas or ***replacement*** with a high purity inert gas, or by a combination of both methods.

Evacuation is the removal of all gases from the piping system by pulling a high vacuum on the system. While this might appear to be the simpler of the two methods, it has four drawbacks:

1. It is impossible to attain a perfect vacuum, so that some of the gas will remain in the system.
2. A substantial amount of time is required to reach even a moderate vacuum in all portions of the system.
3. Due to line conductance, it is difficult to remove the gas from portions of the system furthest from the vacuum pump.
4. High vacuum pumps are expensive and exposure to process gas may result in high maintenance costs.

For these reasons, evacuation is normally used only in conjunction with replacement.

The most commonly employed method of purging is replacement of the undesired gas with a high purity inert gas (the purge gas) which does not react with either air or the process gas, nor pose any other of the previously mentioned hazards. Nitrogen is the most common purge gas, but argon and some others are used in certain applications.

Replacement is accomplished by either ***displacement*** or ***dilution***.

Displacement is the replacement of the undesired gas by a purge gas without intermixing of the two. In theory, displacement would be a simple, rapid means of purging, but in practice it is impossible to introduce a gas into a piping system without intermixing with the gas already in the system.

Dilution is the reduction in concentration of an undesired gas by the addition of purge gas. The amount of the undesired gas does not change, but as more of the purge gas is added, the concentration of the undesired gas (percentage of the total amount of gas present) decreases.

Displacement and dilution are somewhat idealized concepts; practical purging methods generally employ a combination of the two. Two methods are commonly employed: ***continuous flow purging*** and ***cycle purging***.

Continuous flow purging is the continuous introduction of purge gas at one end of a piping system, with continuous removal of a mixture of the two gases from the far end of the piping system. In simple systems, such as tubing runs, the displacement effect is considerable, with much of the undesired gas rapidly driven out at the exit end of the tubing.

In complex system containing branches and dead end cavities (typical of many delivery systems), the situation is considerably different. There is little or no displacement of gas in the branches and dead end cavities, and the dilution of gas in these portions of the system is a very slow process. For this reason, continuous flow purging is not a very effective purging method for most high purity gas delivery systems.

Cycle purging is the alternate introduction of purge gas into a system (pressurization) and release of the mixture of purge gas and the undesired gas from the system (venting).

Dilution is achieved by the introduction of purge gas and the amount of undesired gas is reduced by venting the mixture, leaving a lesser amount of the dilute mixture in the system. This process is repeated, with increasing dilution after each pressurization/venting cycle.

In theory, the concentration of undesired gas after one cycle is:

$$C_1 = C_0 \, (P_v / P_i)$$

After n cycles, the theoretical concentration is

$$C_n = C_0 \, (P_v / P_i)^n$$

Where:

C_0 = initial concentration of the undesired gas (usually assumed to be 1.0, or 100%)
C_1 = concentration after one cycle
C_n = concentration after n cycles
n = number of cycles
P_i = absolute purge gas inlet pressure
P_v = absolute pressure to which the system is vented

When the venting pressure (P_v) is less than atmospheric pressure (14.7 psia at sea level), the procedure is referred to as ***Vacuum Assisted Cycle Purging***.

The above equation is useful as a qualitative guide. Purging efficiency is increased by increasing the purge gas inlet pressure, reducing the venting pressure, and/or increasing the number of cycles. Performance can be further improved by proper system design, such as minimizing branches and dead end cavities.

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