Recommended mass flow controller purging procedure

UNIT

Technology Update

Changing out mass flow controllers in process gas systems may be necessary from time to time for servicing. Many process gases are poisonous to humans in very low concentrations. Gases within the atmosphere are likewise usually "poisonous" to semiconductor processes.

purging procedures

A number of process gases react with the moisture and oxygen in the atmosphere to produce corrosive or contaminating by-products. These by-products can damage the MFC, the gas system or the semiconductor process in extremely low concentrations. It is absolutely necessary in these cases, therefore, to thoroughly purge the mass flow controller and associated gas plumbing both before and after replacing the MFC.

Purging is a process of flushing the system with very pure inert gas to dilute and replace the unwanted gas in the system. Simple purging, flowing an inert gas through the system for a period of time, is not sufficiently effective for high-purity gas systems. It is not possible at all for systems containing valves which have failed in the closed position. "Cycle purging" which is explained below, is usually the most effective method of flushing the gas system. Before removing the MFC all traces of reactive process gas must be purged out. After installing an MFC, moisture and oxygen must be likewise purged out before readmitting process gas.

Where the system contains an inert gas such as nitrogen, purging before removing an MFC may not be necessary. Because they may cause unwanted reactions elsewhere in the system, water vapor and oxygen from the atmosphere must still be purged out after an MFC is installed. If there is any question whether a process gas is reactive or inert, the safest course of action is to assume that it is reactive and thoroughly purge the system.

The MFC and gas system may contain a contaminating gas in several different ways. The system obviously contains gas within its internal volume. Gas is frequently also adsorbed on the system's internal surfaces. These surfaces are surprisingly large on a molecular level. Gas may also be diffused in polymeric materials within the system such as Teflon® in filters. Finally, gas may reside in the small spaces between parts that are in nominal contact with each other or within small surface imperfections. The gas in the major internal volume of the system can be swept away quickly. Gas adsorbed on the surface or shunted aside in "dead legs" of the system not swept by flowing purge gas trickles out slowly. Gas adsorbed on the surface in tiny unswept nooks and crannies of the system can only be removed with very thorough cycle purging. In particular, water vapor from the atmosphere is almost instantly adsorbed on the internal surface of the MFC or gas system and clings to these surfaces very tenaciously.

Cycle purging is a process where the system is repeatedly pressurized with inert gas and then partially evacuated. The precise pressure levels to which the system is pressurized and evacuated are usually not as important as the number of complete cycles of pressurization and evacuation. For example, the system may be pressurized to 20 psi above atmosphere and then evacuated to 10 psi or more below atmosphere.

These sub-atmospheric vacuum levels can be readily generated with an eductor or aspirator built into the system powered from the purge gas supply. Cycle purging brings fresh purge gas into the system with each cycle and likewise removes purge gas mixed with the contaminant gas(es). Cycle purging also flushes unswept areas, "pumping" them as the purge gas pressure oscillates. To be fully effective, cycle purging should be repeated as many cycles as possible up to 100 or more cycles.

Only an experimental analysis can determine how many cycles of purging are necessary to sufficiently purge a particular system. The figure given here, 100 cycles minimum is given as a general guideline only and may not be sufficient in every case.

Cycle purging should be automated. While it is possible for a human to actuate hand valves to purge a system through 100 cycles, experience has shown that such activity is so repetitive and boring that short-cuts are eventually taken. As a result, MFCs removed from corrosive gas systems which are manually purged are often still contaminated enough to thoroughly corrode internally after being exposed to air. If these MFCs were not really malfunctioning before such treatment, they are surely dead afterwards. If the MFC is not effectively purged, the portion of the gas system, which is exposed to the atmosphere when the MFC is removed, is usually not effectively purged either. The resulting contamination can spread throughout the gas loop necessitating complete and expensive replacement.

Research has shown that the number of purge cycles is more significant than the duration of the cycles or the level of pressure and vacuum. In simplified terms, this is because unwanted gas within the system diffuses or desorbs into the purge gas at a rate which is inversely proportional to its concentration in the purge gas. The maximum removal rate is therefore achieved when fresh purge gas is first introduced into the system. As purge gas sits within the system, the relative concentration of unwanted gas within it increases very quickly. As the concentration increases, the removal rate slows down. To maintain a high removal rate, purge gas must be frequently cycled through the system. The actual concentration of unwanted gas within the purge gas may always be quite low. However, the concentration of unwanted gas is essentially zero in the pure purge gas and can quickly rise many orders of magnitude while still remaining infinitesimal.

If you have any questions regarding MFC auto-zero or any other technical questions, please call the Celerity Applications Engineering Department at (714) 921-2640 or visit us at www.celerity.net.

Note: You may wish to refer to Unit/Air Products/Lam joint purging research article. The article appeared in the March 1995 issue of Solid State Technology and is titled "Optimizing the UHP gas distribution system for a plasma etch tool" for more in depth information about this subject.

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