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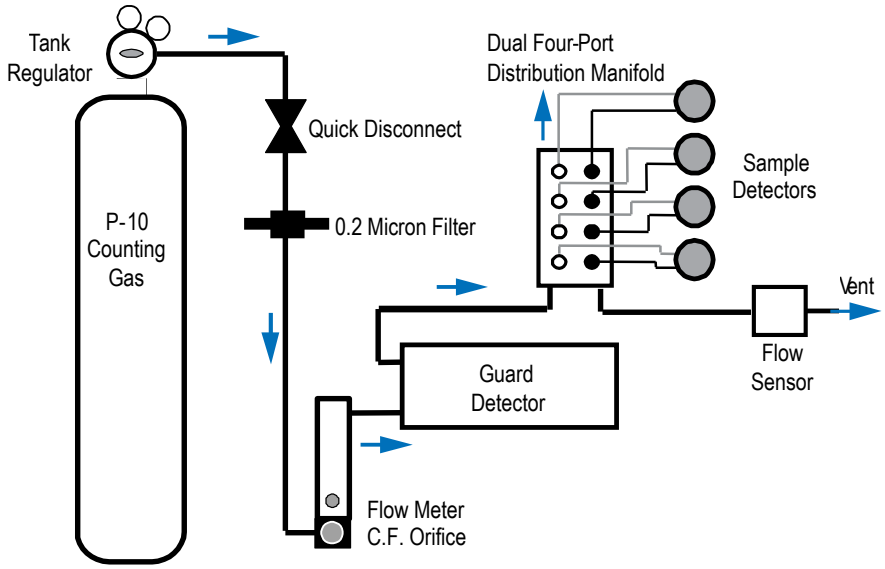
Application Note AN-0807-1

Multi-Detector Gas Flow Considerations

Overview

Protean's model MPC-9604 is a multi-detector instrument utilizing gas flow proportional detectors. It uses P-10 (10% methane, 90% argon) counting gas that is usually supplied from a pressurized tank through a two-stage regulator and pressure reducer. Two MPC-9604s may be supplied from one regulator using an appropriate splitter tee. Because of the consumption rate, operating more than two MPC-9604s from a single tank is not recommended



The MPC-9604 uses a quick-disengage connection for its external gas access. Internal to the instrument the gas first flows from this connection through a replaceable 0.2 µm particle filter. This filter prevents dust and other material from entering the unit and causing damage.

The nominal, factory-recommended gas flow rate for the MPC 9604 is 60 cc/min (i.e., 0.127 SCFH). The flow may be visually monitored using the rotameter style flow meter located on the front panel of each MPC-9604. This non-adjustable flow is determined by a precision, critical-flow orifice (located on the inlet of the flow meter) in conjunction with the secondary pressure setting of the two-stage pressure regulator installed on the gas supply tank. The critical-flow orifice helps protect the fragile detector windows by limiting the gas flow in the event of a pressure surge.

From the flow meter the gas first flows through the guard detector and then to a dual, four-port manifold that distributes it in a parallel fashion to the four inlets of the sample detectors (clear tubing). The gas outlets of the four detectors (white tubing)

are routed to a second four-port manifold where the expelled gas is collected and monitored using an exclusive electronic flow sensor. This sensor is adjusted to trigger a fault condition if the gas flow drops below a safe (from a performance standpoint) operating level. This level was determined through experimentation to be approximately 30 cc/min or 0.064 SCFH. Protean refers to this gas distribution method as *Gas Pro*.

Note: The flow sensor vent should never be blocked nor should the vent's tubing be extended. To do so could rupture the detector windows.

Parallel vs. Serial Fed Gas Distribution

The MPC-9604 implements a parallel feed scheme for its four sample detectors that follow the guard detector. In contrast, most manufacturers use a serial fed technique to distribute the gas to all or a portion of the detectors in similar multi-detector systems. Serial fed schemes may minimize the gas consumption but it creates other problems.

Interrupted Gas Flow Causes Erroneous Data

The weakest link in a thin windowed gas flow detector is the window itself. It is susceptible to rupture or damage from excessive gas pressure and/or from physical contact with samples. If a window is breached it creates two problems. First, if it is not detected and appropriate action not taken, any subsequent analysis in the breached channel is erroneous. Second, a breach in any detector interrupts the gas supply to all subsequent detectors in the series such that data from those detectors are erroneous as well.

Only Protean monitors gas flow as it exits the detectors and reacts to breaches in gas flow that would otherwise result in erroneous data. Other manufacturers monitor gas pressure or flow going into the system – not out. Assuming that because gas is going into the system means that gas is flowing through the detectors is not a valid assumption!

Unstable and/or Inconsistent Performance

Another problem encountered with serial fed schemes is inconsistent performance. Every manufacturer tries to build its detectors to a standard such that each channel in a multi-detector system looks and acts the same as the others. It has been proven in numerous field studies that this is almost never observed with serial fed gas-flow detectors. The reason is simple.

There is a pressure drop across each of the detectors in a serial fed scheme. The entrance windows for these detectors are so fragile that the danger of damage limits the maximum pressure that may be applied thus compensation for losses by increasing the pressure is a limited option. This limitation often results in gas starvation in the last detectors in the series. At the very least, a

decline in efficiency is often observed from the first to the last detector in the series.

Cross Contamination

Yet another potential problem with serial fed gas flow schemes is cross-contamination. If a detector window is ruptured and contamination enters a detector, it is possible for that contamination to be swept from one detector to another by the gas. This is not often the case but it has occurred and when it does the user faces an expensive (non-warranty) service issue.

Detector Isolation

To use a system is to expose it to the possibility of window contamination or damage. Sooner or later this happens on all systems and the question becomes how easy is it to recover or continue working with a partially disabled system.

Channels with elevated backgrounds due to contamination will be uncovered during normal daily QC checks. Affected channels may be tagged for non-use while other channels continue in operation but what about channels with ruptured windows? How easy is it to isolate those channels such that the other channels may remain in use?

With Protean's parallel fed gas flow it is a matter of determining which detector is causing the problem and isolating it by closing (pinching off) its gas lines. The inlet and outlet lines of each detector are routed through simple pinch devices for exactly this purpose. These are accessible from the front of the instrument by lifting the cover. No lead bricks and no detector assemblies must be removed from the shield. The detectors may be easily removed through front access, repaired and/or replaced, or left alone waiting until a more convenient time. In the mean time the other channels may remain in use.

On the other hand, systems that utilize serial fed gas flow schemes usually lose use of the breached detector as well as all detectors down stream of the breach. With serial fed schemes it is almost impossible to replace or repair defective detectors without temporarily disabling all detectors in the unit.

Common vs. Independent Entrance Windows

The reason why high performance proportional counter detectors require a continuous flow of gas is because they have ultra thin entrance windows. The reason they need ultra thin entrance windows is because thick windows will absorb the alpha and/or beta particles that are to be measured – the less dense the window the higher the alpha and beta counting efficiencies – the less dense the window the easier it is for the counting gas to escape – the more gas that escapes the greater the need for increasing the gas flow.

Some suppliers of multi-detector systems use a large common window. This is less expensive than individual, easily-changed windows but presents other problems. Large windows are difficult to change and when they are necessitate the recalibration of all affected detectors. Large windows balloon or bulge with changes in gas flow and barometric pressure, thus affecting counting efficiencies on individual detectors. Ballooning often deforms the material causing permanent damage to the window. If this bulging is to be minimized the window material must be denser which also decreases the counting efficiencies.

Protean uses ultra-thin windows that are individually field-replaceable. These ultra-thin windows optimize counting performance and are easily changed while remaining inexpensive. The MPC-9604 is the only instrument that allows front panel access to detectors for fast and easy window replacement. Protean's windows are less than 30% of the cost of other manufacturers offering detectors with individually replaceable windows.

Factory Recommended Gas Flow Rate

In the first paragraphs it was stated that the nominal, factory recommended gas flow rate for the MPC-9604 is 60 cc/min (i.e., 0.127 SCFH). This is a conservative value obtained when the secondary pressure of the two-stage tank regulator is adjusted for 10 PSI. Increasing and decreasing the secondary pressure will slightly increase and decrease the gas flow rate accordingly.

If the flow rate is decreased below 30 cc/min the flow sensor may trip and prevent the system from counting. The critical-flow orifice will attempt to hold the flow rate constant at 60 cc/min even when the secondary pressure is increased above 10 PSI. The secondary pressure should not be increased beyond 15 PSI otherwise the barbed gas fittings might separate from the tygon tubing inside the unit.

Systems with large volume guard detectors take a long time to fill and thus to stabilize. This is because the air in an unpurged detector must be displaced and replaced by the counting gas at low flow rates and pressures. It is not unusual to see beta background performances continue to improve from 3 to 5 days after an initial system purge. The trade-offs between window density and efficiency was alluded to earlier. The fragility of the windows restricts the purging rate. In other words our recommended flow rate is an optimum rate and represents a trade-off between performance, economy of gas consumption, potential window damage, and purge time.

After the initial system purge it may be safe to decrease the flow rate to a lower sustaining rate to reduce overall gas consumption while maintaining stable performance. Even so, this flow rated should never be decreased below 35 cc/min. Only on-site experimentation aided by *Vista 2000*'s Trending function will determine acceptable post purge flow rates other than the factory recommendation. The following warning is offered prior to such under takings.

Beware of pennywise and pound foolish!

Every culture has its own allegory that serves as a warning to those in search of false economies. The title of this paragraph is attributed to America's Benjamin Franklin in the mid 1700s. In the context of economy of gas consumption the question posed is whether attempts to save pennies worth of gas outweigh the time invested and/or the uncertainties introduced. Only the end user can answer that quest