



Analyzer Sample Conditioning Basics

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INTRODUCTION

Sample handling is comprised of the process tap and process return point, the sample transport system, and the sample conditioning system. This article will cover the basics of sample handling, lag time calculations, sample conditioning, and the principles that govern sample conditioning devices. These subjects are covered with the intent to furnish a short concise overview that will be beneficial to the analyzer technician.

SAMPLE TRANSPORT SYSTEMS

The sample transport system is installed as either a fast loop or a single line configuration. The fast loop system as the name implies creates considerable velocity by taking advantage of a high-pressure sample tap, routing the flow to the sample conditioning system, and then returning the product to a lower pressure return point in the process unit. The fast loop allows fresh process sample at the sample conditioning system, and only the slipstream flow must be conditioned. The fast loop is representative of the process conditions if the pressure and temperature is maintained within specific limits and the sample tap is installed correctly at the correct location.

A single line transport system routes sample to the sample conditioning system but the sample is not returned to a low-pressure process return. When an analyzer is located close to the sample point it is permissible to use a single line transport system if the lag time to the conditioning panel does not exceed 60 seconds and little or no sample conditioning is required.¹ The sample must be maintained below 20 psig to achieve an acceptable lag time. A bypass is generally used to improve the lag time if there is a sample recovery system or venting is acceptable. This configuration is not generally recommended if the distance from the sample tap to the analyzer take-off exceeds 100 feet.

LAG TIME

Distance-velocity lag for a sample handling system is dependent upon the total volume of the sample handling system including all tubing, fittings, and conditioning devices between the sample tap and the analyzer and is a function of the flow rate. Another significant consideration in total system lag time is first-order lag which is the delay caused from mixing of process in sample conditioning devices.

It is useful to remember a few basic examples when dealing with lag time considerations. A sample loop with 100' of ¼" tubing @ 15psig with 2.5scfh flow requires 1 minute lag time. This is a typical single line application. If you increase the pressure to 30psig the lag time will increase to 1.5 minutes. With the same parameters, a standard 3" x 2.5" filter requires 1 minute lag time. Transport lag time should not exceed 1 minute and conditioning lag time should not exceed 30 seconds. A Sheffield separator requires 7 seconds with the above parameters.

Lag time calculations can be very detailed but to stay within the scope of this article the equations used are easily calculated and applied to field situations. The lag time for various tubing sizes and for conditioning devices will be calculated. *See work sheet 1.*

SAMPLE CONDITIONING DEVICES

FILTERS

Most process analyzers require filtration. Because the filter must remove impurities without changing the composition of the sample, inert materials such as glass, stainless steel, ceramics and fluorocarbon are recommended. A Small filter housing designed for sample conditioning in the slipstream is used to minimize filter element replacement and prevent excess lag time. Inside to outside flow direction is recommended for particulate removal, coalescing liquid from gas or liquid from liquid. An outside to inside flow direction is used with membrane type filters and for the removal of bubbles. Either a manual, automatic, or continuous flow drain is necessary for all but the particulate filter application.

Cartridge filters have bowl housing which have too much volume for analyzer application unless a bypass is installed. The miniature version of this type filter will have good results when used with a vaporizer if a low particulate concentration is expected.

Back-Purged filter probes are used when the sample contains a heavy concentration of solids. This should only be attempted with a good backflush design. "The use of a filter in or on the probe is best avoided because of the difficulty of access."¹

Cylindrical Bypass filter element is mounted in a cylindrical steel body. "The major sample flow passes axially through the filter unimpeded. Filtered sample exits at a side connection. The main flow provides a scrubbing action to keep the inside of the tube clean. By ensuring that the major flow is over ten times the filtered sample flow, particles are made to impact the filter element at a shallow angle. This together with the momentum effect of the fast stream, helps to increase the efficiency of filtration without clogging the element."¹

Centrifugal bypass filters utilize the velocity of the process in a circular motion to clean a single surface membrane filter. This filter can also use a hydrophobic membrane to remove water droplets. The optimum flow rate (2-3gpm) should always be observed to furnish the flow necessary to clean the membrane. Excessive particulate loading will increase pad replacement intervals or result in device failure.

Coalesce filter applications create a tortuous path whereby small droplets of liquid impact an obstruction due to the inertia of the sample and join previously impacted droplets to form a larger droplet, which separate by gravity. Generally a wire mesh such as steel wool is used to create the tortuous path. There are also custom fitted devices, which are constructed of one wire with a uniform 60-80 micron mesh, which will precisely fit a small enclosure. In less demanding processes a filter can be used by reversing the inlet flow from the particle removal orientation of outside to inside to a coalescing orientation of inside to outside. The water will accumulate on the bottom of the bowl. Another application for coalescing filters, which will separate liquid emulsions, uses an element similar to the membrane elements, which will allow one liquid to permeate the membrane, and the other will not. A hydrophobic material such as a PTFE filter will allow a liquid hydrocarbon to enter with an outside to inside orientation and the water will be coalesced on the outside of the filter. The water will separate from the filter due to gravity. It should be noted that sample velocity must be kept low and the higher the phase density differential the greater the success rate.

SAMPLE SEPARATORS

Sample separators are used when there is sufficient contaminants and/or immiscible liquids to warrant separating the representative components from contaminants to protect the analytical equipment. This is generally the case when filters alone fail to condition the sample.

Membrane separators are devices employing a polymeric membrane, which strips liquid from sample gas. The separator directs a low flow, low pressure hydrocarbon process stream across a membrane, which will allow the hydrocarbon to permeate. Specific liquids will

be repelled and exit the return. The membranes are submicron rated and will not tolerate particles in the process.

Knock out type separators are used in a gas sample to reduce the flow of vapor, which allow the liquid droplets to separate, by gravity. Some models of knock-out pots also use baffles, which allow the vapor to impact the smooth surface and drain to the side of the enclosure. “The main problem with knock-out pots is their volume and the effect this has on the response time of the stream. For this reason, a knock-out pot should never be placed in a direct line to the analyzer.”¹ This includes all but the smallest of filter housings.

A kinetic separator uses the inertia and gravity inherent in a flowing sample (kinetic energy) and reverses the flow direction of a relatively small volume of the slipstream. Lighter, representative components are separated from the contaminants. This is achieved using a device with one or more small chambers with the flow traveling from top to bottom and positioning a port at the upper end of the chamber to force the slipstream to reverse direction. Contaminates heavier than the process stream cannot negotiate a complete change of direction and will continue to a low-pressure return. Two chamber separators use the second chamber as a polisher chamber. This chamber employs a filter in a similar fashion to the Cylindrical Bypass Filter (CBF) with a vertical orientation. Like the CBF the filter extends the entire length of the chamber and the particulate impacts the walls at a shallow angle. The kinetic separators are also used in single line application with minimal lag time due in part to the lack of first order lag consideration.²

CONCLUSION

Basic sample handling and the majority of sample conditioning can be understood with an overview of the transport systems, lag time concerns, and sample conditioning devices that are basically physical in nature. Proper conditioning of analyzer samples is the single most important maintenance consideration in an analyzer installation. Of the maintenance problems with analyzers, over 80% are related to the sample handling system.¹ The majority of analyzer sample systems the analyzer technician will encounter can be explained by the above descriptions.

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