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POROUS METAL CROSSFLOW FILTERS FOR GASEOUS AND LIQUID PROCESS SAMPLING

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Presented at the
American Filtration and Separation Society Conference

Valley Forge, PA

April 21-24, 1996

POROUS METAL CROSSFLOW FILTERS FOR GASEOUS AND LIQUID PROCESS SAMPLING

The technology for sampling of liquid and gaseous streams has been impacted by two recent developments. First, plant implementation of automated process control requires real time sampling of fluids contaminated with particulates. Secondly, compliance with EPA regulations demands sampling of plant effluents at the discharge point often under harsh operating conditions. Plant operators with an eye on the bottom line are looking for sample extracting devices requiring little or no maintenance, fast response time giving quality results in real time and effective protection of their expensive analyzing equipment. Porous metal crossflow sampling filters offer reliable and accurate solutions for operators. This paper describes the operating principles and typical applications of these porous metal filters.

The design of a porous metal crossflow filter consists of a porous inner tube, a tubular housing enclosure, connections for feed inlet and outlet, and a clean sample port (see Figure 1). Feed flows at high axial velocity through the bore of the porous tube, while clear filtrate is driven by transmembrane pressure radially into the annulus between the filter element and the housing. Solids in the radial flow are retained on the inner element surface. The high axial velocity generates tangential shear on the filter surface controlling the solid deposition thickness. In addition, the solids can be ejected from the filter surface and the pore inlets by reverse flow. Feed flow is maintained during a backpulse cycle to flush the ejected solids from the filter assembly. High axial velocity and backpulsing in place make porous metal crossflow filters self cleaning eliminating the need for media replacement or process downtime.

Liquid porous metal crossflow filters produce between 250 and 5,000 milliliters/minute of clear filtrate pending on the diameter and length of the porous filter tube. This range covers sample flow rates typically required for single analyzers as well as analyzer stations with multiple instruments working in parallel. Differential pressure drop across the filter is less than 10 psid for aqueous feed material. Liquid feed rates range from 2 to 10 gpm. The high feed rate in combination with the low liquid hold-up in the annulus delivers clean sample fluid to the analyzer rapidly minimizing dwell time, backmixing and dispersion.

Gaseous porous metal crossflow filters produce sample flow rates from 1 to 12 liters/minute. Recommended axial gas velocity is between 70 and 100 ft/sec to control the solid deposition layer on the filter surface. On sampling systems without sufficient axial sample flow, an eductor is used to raise the axial velocity. The eductor is driven by compressed gas and located downstream of the filtering section to prevent sample dilution.

Materials of construction are specified for each application. The standard porous media material is 316L stainless steel; Monel and Hastelloy C-22 filter media are recommended for corrosive fluids. In elevated temperature applications, Inconel and Hastelloy X are used. Liquid porous metal crossflow filters typically have removable porous metal elements, while an all-welded design is preferred for elevated temperature gaseous applications.

A 2 micron grade media is installed as the media of choice in the sampling filter based on equipment service life experience. Alternate grades of 0.2 and 0.5 micron for rejection of finer particulates are employed for very sensitive instrument protection. Coarser media: 10, 20 and 40 micron are also. In critical applications, the optimal micron grade is established by pilot testing in the lab or on location.

APPLICATION CASE 1: Refinery Fast Loop Blending Analysis

A petroleum refinery eliminated a host of maintenance problems and analyzer downtimes by sampling fuel blends with a porous metal crossflow filter installed parallel to the fast loop (Figure 2). Before the upgrade, the sample flow passed between the fast loop and the analyzers through coalescing-type and dead-end-type disposable filters to protect the instruments in the analyzing equipment. The fuels that are mixed in the blend header are contaminated with rust, sand, catalyst fines and frequently water droplets. The original disposable filters needed daily replacement that resulted in downtime. Around the clock, on-line blending of gasoline, diesel and fuel oil is a high value operation in refineries and analyzer downtime is expensive. To eliminate these problems, a laboratory size porous metal crossflow filter was first tested on a slip stream to the fast loop. A full scale porous metal crossflow filter was subsequently installed and has been operating for over two years with minimal maintenance. The porous metal filter also eliminated operator exposure to toxic benzene caused by the frequent filter exchanges, and breakthrough of the disposable filters for a safer operating system. The disposable filters often failed at night causing production to lose control of the mixing process requiring costly (both time and money) re-blending; the porous filters reduced not only the disposable replacement costs, but also process downtime. Pay back for the retrofit was three months based on disposable replacements cost savings only.

APPLICATION CASE 2: Petrochemical Plant Wastewater Monitoring

The plant's operating permit requires continuous monitoring of TOC (total organic carbon) , NH_3 and phenolic compounds in the discharge from a biological treatment facility. Clarified wastewater is delivered to the analyzers at a constant rate of 250 milliliters/minute with a porous metal crossflow filter installed in a closed loop with a pumping rate of 20 liters/minute. Due to the changing solids load and the fouling tendency of the wastewater, the porous metal crossflow filter needs frequent backpulsing. Backpulsing is initiated by a timer or by a low filtrate flow alarm. The backpulse is generated by a pressurized air driven piston located in the filtrate outlet line (Figure 3). The piston arrangement prevents gas from bubbling into the filtered sample which would produce erroneous analyzer readings. Samples for the TOC analyzer are generated with a 40 micron media; the NH_3 and phenolic analyzer samples use a 10 micron media. Maintenance work on the porous metal crossflow filters consists of ultrasonic element cleaning scheduled every 4 to 6 weeks.

APPLICATION CASE 3: Stack Gas Emission Analysis

Direct stack gas analysis requires a sample stream free of particulates like soot and flue dust and condensables. Porous metal crossflow sampling filters are used for particulate removal prior to cooling for moisture removal. These filters can handle the high dust loads of fine particulates without plugging. The all-metal filter design provides for leak-tight operation and corrosion resistance at elevated temperatures.

The gaseous porous metal crossflow filters are installed in two locations to sample above the dew points of condensable gas constituents; either in-stack (Figure 4) or outside of the stack wall in a heated box. By sampling and filtering high up on the stack, the analysis response time is increased since only the clean gas sample has to be transferred to the ground level.

Remote stack gas sampling requires, however, an eductor to produce a velocity of 70 to 100 ft/sec in the dust laden sample stream. The eductor, located downstream of the filter to prevent sample dilution, injects pressurized gas which accelerates the dirty sample stream. Both the sample stream and the service gas are returned to the stack for emission containment.

Dilution gas and analyzer calibration gases are added to the clean sample downstream of the filter. Other successful gaseous porous metal crossflow filter applications are in FCCU regenerators, dryers of explosive powders, lime and cement kilns, coal pulverizers, and polyethylene reactors.

Conclusion:

Sample extracting devices for gaseous and liquid processes are critical components for optimal and reliable performance process analyzers and monitoring systems. Porous metal crossflow filters offer a viable option for the design engineer to improve system reliability, to lower maintenance costs in labor and materials, and to provide operating flexibility over conventional sampling probes with disposable filter media.

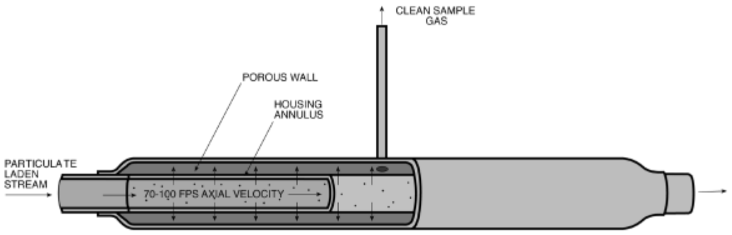

FIG. 1 GASEOUS POROUS METAL CROSSFLOW FILTER

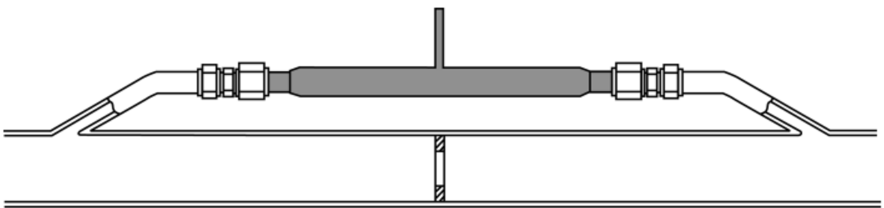

FIG. 2 FAST LOOP SAMPLING FILTER

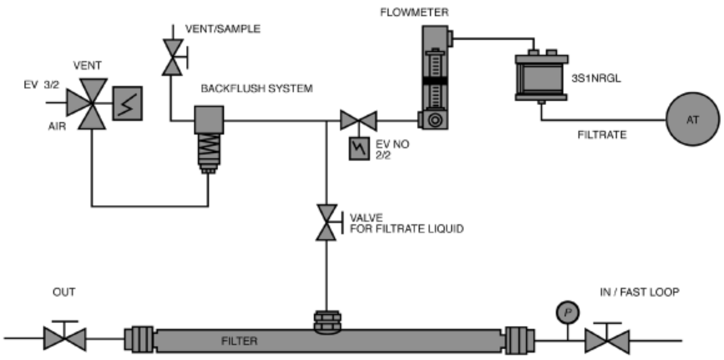

FIG. 3 WASTEWATER SAMPLING FILTER WITH SAMPLE FLOW CONTROL AND MEDIA BACKPULSING

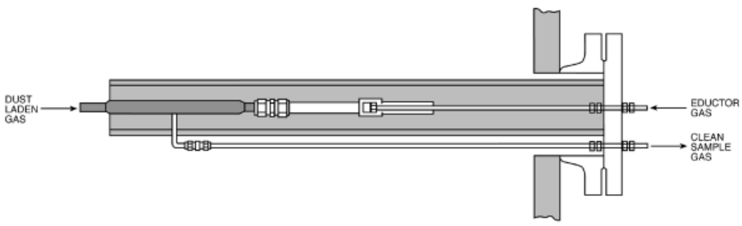

FIG. 4 IN-STACK GAS SAMPLING SYSTEM