How a Magnetic Separator Can Reduce Single-Use Filter Costs

May 2020

3 minute read

Operators working with hydrocarbon gas and liquids, refined products, water and process fluids are continuously managing particulate contamination. These fluids and gasses, along with the facilities that process, utilize, transport and store them, are all subject to contamination from solids, liquids, gasses and other molecular compounds.

Figure 1. Pyrophoric black powder that has bypassed conventional filter elements

Contamination can be introduced to a system or generated within the system itself. To remove it, the oil and gas industry spends billions of dollars on methods like separation, filtration or coalescence. Filtration costs for a single filtration system, let alone for an entire facility, can be in the order of several million dollars per year based on replacement of single use filters; there are many other costs associated with operating these systems as well.

A few real-world examples illustrate this:

a. In condensate service, a sour gas plant operator was spending US$150K per month on filter elements to remove iron sulfides & related sulfur particulates.
b. In diesel fuel service, a refined product pipeline operator was spending up to $200K per month on single-use filter elements to manage product quality.
c. In desalter service, a refiner was spending over $160K per month on filter elements to manage black powder.

This paper reviews many of the challenges that operators are faced with when using conventional surface and depth media filtration systems to remove particulate. It then introduces a cost effective and economic alternative – magnetic separation. Cyclones are not discussed here because they are typically inefficient below 30 microns, and ineffective below 10 microns.

Conventional Filtration Systems

Conventional particulate filter systems employ a filter housing or vessel with replaceable filter elements. Most filter elements are constructed with various materials woven and layered together to collect particulate at the filter's surface and/or in its depth. Filter elements are rated on their ability to remove particles of a specific size from a given stream. Filter media efficiency is typically measured 2 ways, by micron rating and Beta Ratio.

Figure 2. Disposed conventional filter cartridge waste

- Micron rating refers to the size of particles down to which the filter cantrap – this however can be deceiving because it is dependent on the testing methods and standards used to determine its rating. Micron ratings will either be absolute or nominal; both designs have various oversights that lessen their accuracy, the primary oversight is that the lab conditions used to test them do not reflect real-world conditions.
- Beta rating measures the material trapped in the filter in relation to the material that bypasses the filter. It is determined by a multi-pass test where contaminants enter the fluid in varying increments as it circulates past the filter. Because this rating is determined by multi-pass tests, it does not accurately reflect the real conditions of single-pass process flow applications.

With these systems, flow direction in the vessel is described as either inside-out flow (through the inside of the filter and then outward through the exterior of the element) or outside-in flow (through the outside of the filter and then into the filter element). The efficiency of outside-in flow systems is typically less than that of inside-out flow systems.

The use of conventional filter systems introduces a dilemma that pits the trade-off of filter performance (lower micron and absolute/nominal ratings) against filter cost (more frequent replacement the lower the micron rating) against product quality (with impacts to associated equipment reliability and maintenance expenses).

Typical drawbacks of conventional filter systems are as follows:

1. They are an expensive consumable. Filter elements typically cost hundreds of dollars per element, with the unit cost increasing as filter performance increases (ie. smaller micron rating). A typical filtration unit can require dozens of replacement filters per week.

2. They drive higher labor costs and increase personnel exposure. Technician/operator involvement is required to open filter vessels and replace filter elements (this can occur more frequently than every 24 hours).

3. They hold very little contamination when full of particulates. Despite manufacturers claims, dirt holding capacity is often measured in ounces or grams rather than pounds or kilograms. Stated holding capacities are often highly exaggerated.

4. They drive high costs for disposal. This is mostly driven by the volume of waste occupied by the filter element itself, rather than contamination in it.

5. Filter companies make their money off filter-element sales. Filter companies often provide their filter vessels at cost – its typically subject to multi-year sole source filter supply contracts.

6. Absolute filter ratings are typically assumed to be accurate. Most operators do not test downstream flows for particulates that are bypassing these filters. Filter ratings are often derived in lab-based environments with the use of esoteric materials (ie. cactus dust) rather than in real world operating environments.

Figure 3. Damaged strainer partially covered in black powder

Figure 4. Black powder removed during scraper pig runs

7. They can break down and collapse. When this happens, the filter stops doing its job and filter material is sent downstream into flowing media and equipment.

8. They are the most effective just prior to plugging off. This requires either immediate call-out for operators/technicians to replace elements or filter system bypass (or both). Increasing pressure differentials across filter systems also drive higher energy costs to move product.

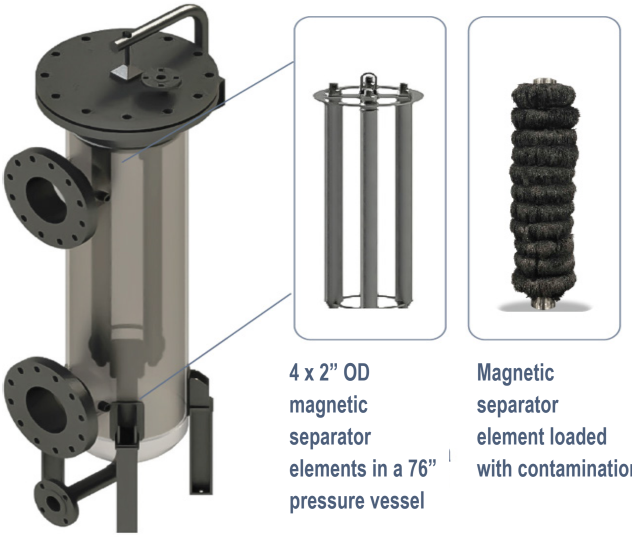
Figure 5. More black powder removed during a pig run

9. They are often not employed in necessary applications. For example, they could protect pumps from particulate ingress if installed on the suction side of pumps, but plugged off filters cause pump cavitation and pump damage.

Despite these drawbacks, conventional surface and depth media filtration systems are till the standard for removing particulates in hydrocarbon systems. This however is changing as filtration alternatives like magnetic separation become more widely understood and deployed across industry.

Magnetic Separation

Magnetic separation systems offer an alternative to conventional mechanical filter systems and have been employed in hydrocarbon processing and pipeline applications predating 2010. These systems are now being used more widely in field gathering, gas processing, long-haul and distribution pipelines, fractionators, refineries, chemical plants, tankage and ship loading terminals.



4 x 2" OD magnetic separator elements in a 76" pressure vessel

Magnetic separator element loaded with contamination

Benefits of Magnetic Separation

These systems rely on the residence time of a fluid or gas within the magnetic fields to remove entrained contaminants. The stronger the magnetic field strength, the greater the ability of the magnetic separators to attract large amounts of particulate contamination all along the size spectrum.

Figure 6. Black powder removed from condensate (petchem facility)

1. A one-time capital expenditure with no opex. Payouts for magnetic separation systems are typically measured in months based on avoided use of filter elements (such as in deployments upstream of conventional filter systems).

2. Drive higher product quality. These systems are highly efficient (over 95%) at removing particulates all the way down below 0.1 microns.

3. Leads to improved equipment reliability and process uptime. Efficient removal of sub-10 micron particulate leads to less equipment failure and reduced unplanned maintenance. In turn, operators see lower costs for equipment maintenance and replacement.

4. No disposable filter elements. The particulate contamination collects on the magnetic elements and is then mechanically wiped from the magnetic elements and disposed. This eliminates the costs associated with the consumption of filter elements.

5. Large contamination holding capacities. Systems typically hold hundreds of pounds of contamination before cleaning is required. This allows for up to 6-month or longer cleaning intervals, depending on the contamination loading.
• This significantly reduces technician/operator involvement with filtration equipment and lowers both labor costs and personnel exposure (ie. 'touch points').
• This also drives far lower disposal costs, as only the contamination is disposed.

6. No fuel or power requirements for day-to-day operation. These systems use permanent rareearth magnetics, not electromagnets. This combined with a bare minimum of consumables results in minimal operating costs.

7. Service lives in excess of 20 years. Systems will operate well in excess of 20 years with no degradation in performance.

8. Low operating pressure differential (dP). Systems operate at sub 0.5 psi dPs when clean, less than 5 psi when full of contamination and typically in the 1.5 psi range when cleaning is required.

Magnetic separation systems can be deployed in any gas and liquid volume application. Systems can be designed for temperatures up to 600 °F (300 °C).
Further, they are deployable in many applications where conventional filtration systems cannot be used effectively. For example, applications with high-volume liquid that requires sub-10 micron particulate removal, or pump and compressor side applications where high-pressure differentials and low flow cannot be tolerated.

Magnetic separation is a proven process for the bulk removal of particulates all the way down below 0.10 microns. They offer a range of more cost-effective benefits than traditional particulate contamination removal systems. Magnetic separator systems are a highly-effective solution in a world where cost efficiency, sustainability and safety are required by facility owners and operators.

Figure 7. Black powder removed from desalter water (refinery)

Figure 8. Black powder removed from LPG exports (ship terminal)