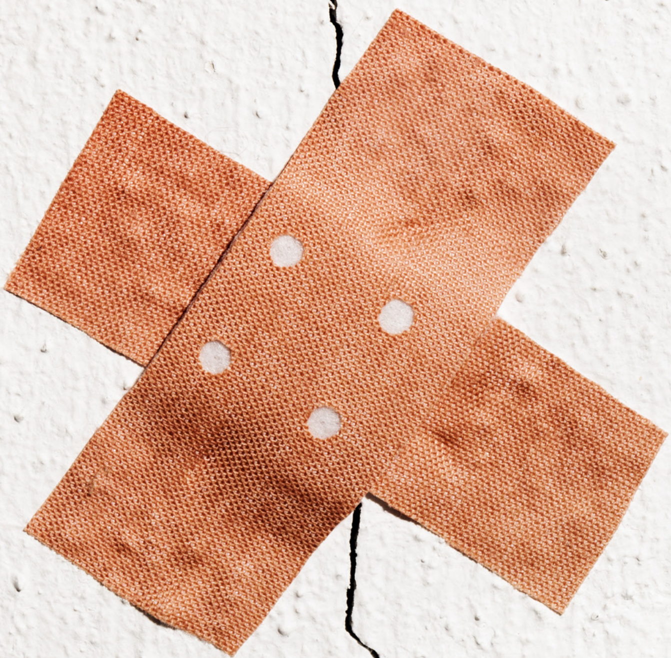
BEYOND BAND-AIDS



Contaminants cause constraints. **Mathews Thundyil and David M. Seeger, Transcend Solutions LLC, USA,** present a methodology to help operators move beyond addressing symptoms to finding solutions to improve operating efficiency.

Operators in the oil and gas industry experience many different issues in the daily operation of their facilities. Examples of operating issues range from sudden pressure increases to fouling, foaming, and may lead all the way to a shutdown. Many operators struggle to determine why these issues are plaguing them and why the same issue can repeatedly haunt them. The traditional approach is to address the symptom – for example, if the tower foams, add anti-foam; if the heat exchanger fouls, get a stand-by exchanger; if the catalyst bed reaches end-of-run due to pressure drop, add dispersants and anti-foulants. These and many more symptoms are tolerated by operations and maintenance in the upstream, midstream, and downstream processing plants throughout the world. The 'band-aid' approach never solves the root cause. Engineers and operators struggle with lost throughput and increased operating cost. Worse, they build new facilities that will continue to face old problems. The costs of these constraints range from economic (throughput, energy, efficiency, reliability and maintenance costs), to environmental and safety.

In countless cases, a careful analysis of the operating issue will reveal that the root cause is related to trace contaminants in the system. Most facilities do not recognise the role played by trace contaminants because these contaminants are so difficult to isolate and identify. In addition, while they have equipment ostensibly intended to separate or remove contaminants, these pieces of equipment are often ineffective. The medical analogy is to discover the relationship between germs and disease. Humanity has suffered the effects of disease without really understanding the causes, using cures that were often worse than the illness itself. All this changed when we realised that all that is needed is simply to control the germs. Similarly, the effective removal of offending contaminants is usually the root cause solution that will allow the operation of these processing units at or beyond their design efficiencies. This article will focus on the removal of solid contaminants from liquids, using disposable elements, i.e., the most effective method for trace contaminant removal.

The 4-Cs that drive effectiveness of installed separators are:

- Capability – can the vessel or internals capture and remove the contaminant?
- Compatibility – are the elements and vessels compatible with chemical and process conditions?
- Characterisation – do the operators have a means of determining efficacy?
- Cost – how can the cost of contaminant removal be minimised?

Capability

Many factors impact the capability of a vessel and element configuration to effectively remove contaminants. These include the vessel design, the internal media technology, the sealing mechanism, and operator access to elements.

Vessel design

Vessels for solids removal can be orientated either vertically or horizontally, whilst the fluid flow configuration through the element can be from the outside-in, or inside-out. The vessel orientation or flow configuration does not generally impact contaminant removal capability. It is preferred if the vessel has a full opening closure – allowing easy operator access to the replaceable elements. If the operator's access to internals is through a manway, or if the element replacement process is cumbersome, it is inevitable that the system is more likely to operate ineffectively. In general, a horizontal flow configuration with a full opening closure is preferred, since operators can install and remove elements ergonomically.

Media technology

The actual mechanism for solids removal from liquid streams is for the solid to be trapped on or within a porous matrix. If the matrix is such that the contaminant is either unable to be captured, or can be released following capture, the media will not be able to function at the level required.

Element design

Elements can be constructed in a range of diameters and lengths. The optimal element diameter and length can be determined based on maximising packing density, media availability within a given vessel diameter, and maximising operator ergonomics. Also, there is a limit to how big an element can be: the smaller the element, the larger the number of elements that are needed. The optimum is often dependent on fluid properties, contaminant characteristics and operating criteria such as differential pressure.

Sealing mechanisms

Elements that seal with a positive O-ring seal are best in comparison to those that seal with a knife-edge on flat gaskets, or a knife-edge on filter media. Even the most efficient media technology will not be effective if the contaminant can bypass the filter around the seal; gaskets have been observed to fail at sealing.

Compatibility

Compatibility of the components of the filter element with the chemical and process conditions should be an obvious requirement. In some cases, the process chemicals, process upsets, or vessel safe-out procedures can introduce compatibility considerations that are not obvious.

The materials of construction for the endcaps and liners of the separator elements need to be matched to the service requirements, e.g., filtration of brine water may require a high-end alloy or something as simple as nylon. The media also needs to match the service, e.g., neither polyester nor polypropylene are advised for use in amine systems. The key compatibility determinations include:

- Compatibility with process fluids.
- Compatibility with process temperatures.
- Compatibility with episodic conditions such as process upsets, steam-out, etc.

Characterisation

Removal efficiency

No widely accepted standard for removal efficiency exists in the industry. As a result, different manufacturers use different ratings (e.g., nominal, absolute, beta-rating), and multiple test methods are available for determining efficiency and capacity. Even if there was a reliable and consistent test method, it is often necessary to conduct field tests that validate whether the desired level of fluid quality is being achieved. A system specific definition of acceptable fluid quality is required.

Change-out conditions

The elements need to be replaced when they are spent. The easiest way to determine when replacement is necessary is to monitor either flow or pressure drop across the elements and define a change-out value. Further, the measured data should be transmitted to a control room with a retrievable historian, rather than manually acquired by the shift operators. If the elements do not show a pressure drop increase, or a flow reduction under constant pressure drop conditions, it is likely that there is fluid bypass of some kind.

Cost

Element size

As the element diameter and length is increased beyond a certain point, considerable additional componentry needs to be added to maintain structural rigidity and element mechanical strength.

Media technology

The choice of media material and available media for fluid flow tends to drive both element cost and the relative cost of dirt removal (US$/mass of contaminant).

Media velocity

For a given element and media type, lowering the flow per element tends to increase total dirt capture at the same differential pressure. Of course, lowering the flow per element will require a larger vessel, thereby driving up capital cost. Increasing the element dirt capture capacity by reducing flow per element has the effect of also increasing mean time between change-outs, which is important from an operations and maintenance standpoint. Determining the optimal vessel size that maximises run life while minimising operating cost and NPV is complex, but can be done by sophisticated separations technology companies.

Case studies

Reducing operating cost

A refiner operated a single filter vessel on an amine system, for solid/liquid separations, and was considering installing a second vessel to allow the plant to operate with a 100% standby, i.e., 2x 100% operation. The existing vessel required frequent filter change-outs, occasionally as often as every 18 hours, and the operators wanted options to reduce that frequency. The first step was to use a high-efficiency, high-capacity media. This media was able to increase run life up to 7 – 10 days while improving fluid quality. A second step was to reduce the frequency of element change-out and provide uniformity by using the same separator element currently being used in the unit. To reduce the frequency of element change-out, a larger vessel would be required. The larger vessel would contain more elements and therefore offer a lower overall media velocity. The current vessel had 21 elements and the new, larger vessel has 42 elements. The increased CAPEX for the larger vessel was weighed against reduced operating cost of filter change-outs.

Data was gathered immediately following the installation of the larger vessel and the information was compared to previous data gathered while operating with the smaller vessel. The separator element run life vs differential pressure for the existing housing (with 21 elements) and the new housing (with 42 elements) is provided in Figure 1.

Figure 1 shows that for the same terminal differential pressure of approximately 35 psi, the vessel with 2x the number of separator elements has 33 days compared to 8 days of run life with the original smaller vessel. The ratio of run life (33 days compared to 8 days) is approximately 4x, as expected. Since the operating flow rate is constant, the increase in run life corresponds to a 4x increase in treated volume. The annual OPEX was reduced by approximately US$85 000 and that paid back the increased CAPEX for the larger vessel well within the first year. In this case the reduction in OPEX justified the increased CAPEX for the larger vessel.

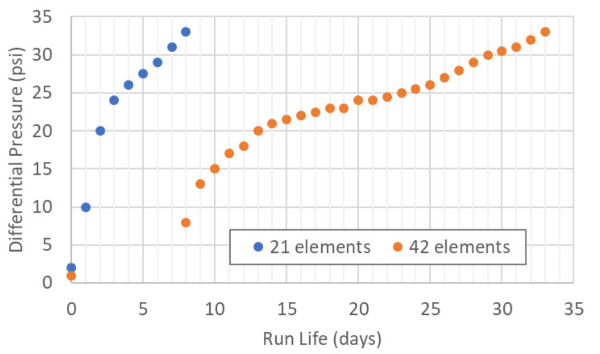


Figure 1. Run life comparison.

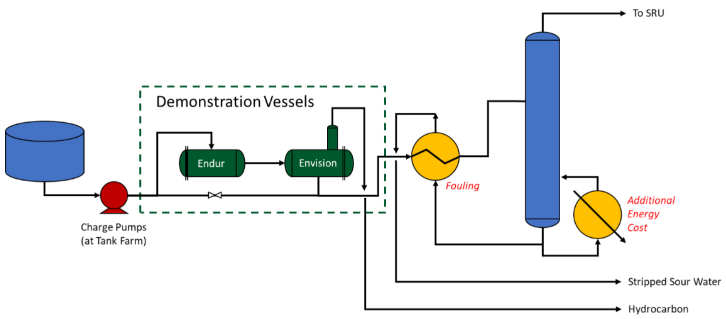


Figure 2. Simplified PFD of the TORSEP installation.

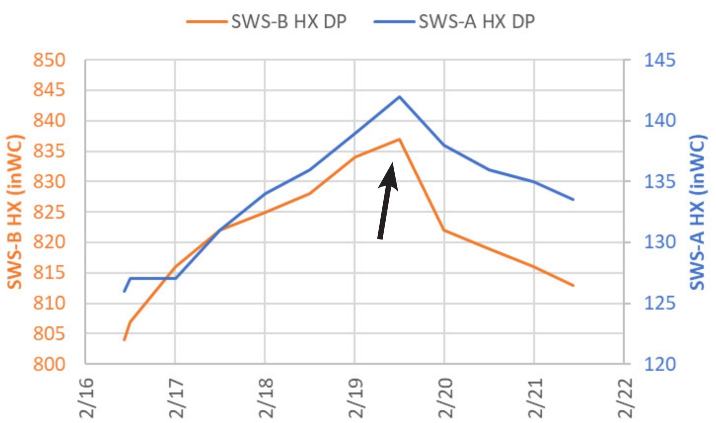


Figure 3. Operating data from TORSEP unit (arrow indicates where TORSEP system started).

Heat exchanger fouling – sour water stripper

A refiner was forced to clean the heat exchanger in the sour water system approximately every 3 months due to fouling. The heat exchanger fouled with coked hydrocarbons and solid particulates sticking to the exchanger surface, causing reduced heat transfer efficiency and increased pressure drop (DP), which created the need for their heat exchangers to be cleaned. To perform the cleaning, the system was shut down, drained, purged and cleaned followed by reassembly. The complete cleaning process caused the refiner to incur significant OPEX.

A root cause analysis determined that the contaminants were both solids and liquid emulsified hydrocarbons. The appropriate solution was to remove both the solids and the liquid emulsion. The Transcend TORSEP™ system was designed specifically for solid and emulsion separation. The system was added downstream of the charge pumps from the sour water tanks, as shown in Figure 2.

The 4-Cs (focus on capability, compatibility, characterisation, and cost) approach required a definition of the contamination and the system capability to remove those contaminants, validation of compatibility in aggressive sour service, development

Figure 4. Sample on the left was taken from upstream of the TORSEP system and contains solid particulates and hydrocarbon liquid. Centre sample was taken at the outlet of the system and is free of both particulate and hydrocarbons. Sample on the right is the hydrocarbon recovered.

of a mechanism to validate performance, and ultimately to evaluate overall operating cost.

As discussed previously, the DP across the heat exchanger in the sour water system increased until the operators were forced to shut down and clean the exchanger. The light blue and orange lines shown in Figure 3 are the DP signals in units of inches of water column. The data, provided by the refinery, shows that the constant upward trend of the sour water exchangers DP stopped within minutes of bringing the TORSEP system online. Following start-up, the upward trend stopped and even slightly reversed trend. The DP has remained nearly constant since the start-up and the refiner has not had to shut down to clean the heat exchanger.

Samples taken from the inlet and outlet of the system are shown in Figure 4. The picture on the left is a sample of the inlet which has hydrocarbons and solid particulates, the picture in the middle is a sample from the water outlet showing only a clear water phase, and the picture on the right is a sample of the hydrocarbon outlet. Hydrocarbon was drained out of the boot until a water phase also appeared.

The case study successfully demonstrated that heat exchanger fouling was mitigated immediately upon start-up of the system. Hydrocarbon recovery was demonstrated, and filter change-out frequency was validated as reasonable and acceptable by the customer, i.e., the solid particulate filters did not have to be changed out more often than expected. The system was a success.

Summary

Operators in the oil and gas industry have been known to cope with operating conditions of foaming, fouling, plugging, poor quality fluids production, etc., and accept shutdowns or frequent equipment cleaning as a routine way of life. Many engineering companies, and the filtration companies that serve them, design filter housings with a simple 'clean pressure drop' specification that ignores various metrics of importance to operators.

The 4-Cs allow an end-customer to move from 'band-aids' on symptoms to solutions that remove the critical contaminants at the desired efficiency, while reducing overall costs, and improving safety, ergonomic and maintenance metrics. The 4-Cs methodology requires an integrated approach that understands process engineering, separation 'know-how' and technology customisation.