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Preparation, Separation,
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Application Note

Best Practices for Managing Reverse Pressure Filter Impact

Optimizing Millipak® and Millidisk® filter performance in every process

The unique design of the stacked disc Millipak® and Millidisk® filters includes a membrane supported by bonding to a molded plastic disc. These plastic support discs do not absorb liquid resulting in very low hold-up volume, maximizing product recovery. These unique stacked disc filters were designed for operation in the forward flow direction and have a reverse pressure limit of 10 psi.

During normal processing, flow through the filter is driven by an upstream pressure source, either a gas pressurized feed vessel or a pump, Figure 1. Upstream pressure (P1) will be higher than downstream pressure (P2), and the magnitude of the pressure drop across the filter will depend on operational parameters such as flow rate, liquid viscosity and degree of membrane plugging.

At the end of the process, the fluid flow may be terminated by closing the gas pressure and venting the feed vessel, turning off the pump, or closing valve 1 (V1). In all cases, if valve 2 (V2) remains open, downstream pressure will be lower than upstream pressure, and filter performance should not be a concern.

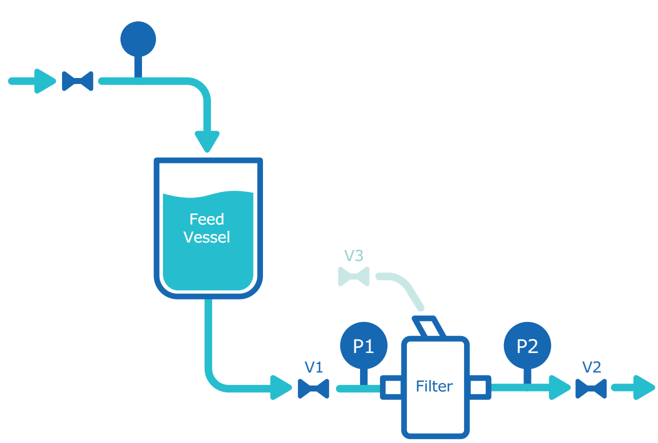

Figure 1

Normal operation. V1 and V2 open. P1 higher than P2.

In this tech brief, we review two operational conditions that may impart excessive reverse pressure in a process that is only expected to have forward flow:

a) accumulated downstream pressure venting;

b) water hammer.

Highlighting these potential problematic conditions may help guide ‘best practices’ for your filtration operations.

The life science business of Merck KGaA, Darmstadt, Germany operates as MilliporeSigma in the U.S. and Canada.

a) Excessive Reverse Pressure: Accumulated Downstream Pressure Venting

Reverse pressure can be created at the end of a filtration process by an incorrect sequence of valve actuations. During normal operations, process flow should be stopped by venting the upstream vessel, turning off the pump, or closing valve 1. However, if the process flow is stopped by closing valve 2 before closing valve 1, the downstream pressure will increase until it matches the upstream pressure, Figure 2.

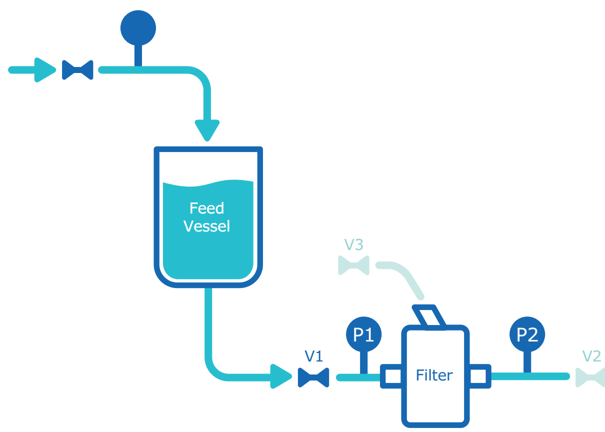

Figure 2

Pressure across filter when processing stopped by closing valve 2 (V2), with valve 1 (V1) open. P1 = P2.

If valve 2 is closed and the upstream pressure is relieved by opening the filter housing vent valve (V3), or venting the feed vessel, P1 will be lower than P2 and the pressure accumulated downstream of the filter will impart reverse pressure on the membrane, Figure 3. The magnitude of reverse pressure will depend on the system pressure, the downstream volume, rate of venting, and fluid flow.

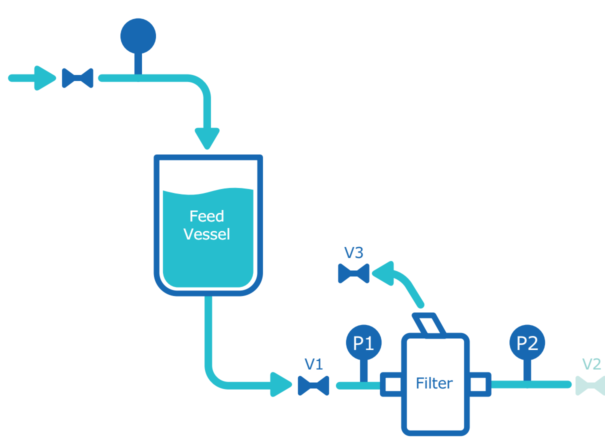

Figure 3

Reverse pressure created across the filter when processing stopped by closing valve 2 (V2), and pressure relieved by opening valve 3 (V3) (P1 < P2).

Table 1. Impact of valve closing on direction of pressure across the filter.

Mode	Valve Position	Relative Pressure	Direction of Pressure Across Filter
Normal operation during run	Valve 1 and valve 2 open	P1 more than P2	Forward
Normal operation ending run	• Close gas pressure • Vent feed vessel • Turn off pump • Close valve 1	P1 more than P2	Forward
Accumulated downstream reverse pressure ending run	Valve 2 closed, valve 3 opened or feed vessel vented	P1 less than P2	Reverse

If defect analysis indicates likely reverse pressure failure, the filter venting operations should be reviewed to determine if downstream pressure venting was performed correctly, Table 1. Depressurization at the end of a run is best performed in the following sequence:

- Close the gas pressure to the feed vessel
- Turn off the pump and close the upstream valve
- Close the downstream valve

b) Excessive Reverse Pressure: Water Hammer

Another potential cause for excessive reverse differential pressure is water hammer, which occurs when fluid flow is rapidly stopped, Figure 4. If, during dynamic flow, valve 2 (V2) is closed rapidly, the energy of the moving fluid will dissipate by moving back and forth in a wave movement in the closed system; this phenomenon is known as ‘water hammer’.

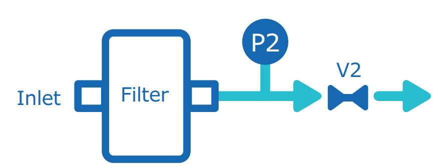

Figure 4

Filter device with valve 2 (V2) and downstream pressure gauge (P2).

Figure 5 illustrates pressure changes caused by this wave movement. Importantly, the reverse pressure pulse during water hammer can be greater than the forward pressure driving flow. Water hammer has been known to damage all types of piping materials including steel, copper, and PVC, and would certainly damage a membrane filter.

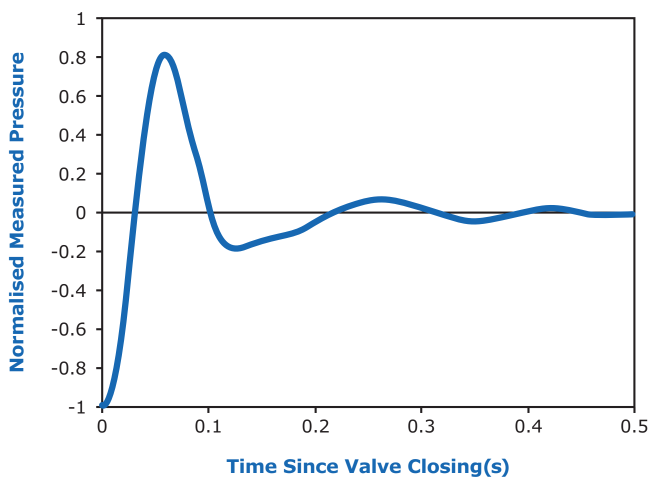

Figure 5

Differential filter pressure pulses due to water hammer

To minimize the likelihood of water hammer when using stacked disc filters, it is recommended to:

- Close the upstream valve 1 (V1) before closing the downstream valve 2 (V2)
- Close valves slowly
- Use lower flow rates or smaller diameter pipe
- Place a pressure accumulator in vulnerable piping

Conclusion

To minimize potential damage from excessive reverse pressure over the stacked disc filters, it is always best to stop flow by first closing the valve upstream of the filter, allowing the pressure across the filter to quickly dissipate. Following this practice will eliminate any potential for excessive accumulated downstream reverse pressure or water hammer damaging the filter.

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