Using New Technology To Minimize Cartridge and Bag Filtration Costs

By: John Hampton

Increasing filter life is the most crucial element in reducing filtration costs. Filter life is directly related to a filter's dirt holding capacity. It can be defined as the total volume of fluid that passes through a filter before reaching the maximum operating differential pressure.

Maximizing Filter Life

Fluid flow density (gallons per minute per square foot of filter media) is the controlling factor in determining filter life. Longer filter life is a direct result of lowering the fluid flow density. Since flow density is determined by flow rate and filter media surface area, filter life is increased when the flow rate is reduced or when surface area is increased. The only limitation to this concept is that the filter element construction must contain enough void space to hold the additional filter cake that is generated.

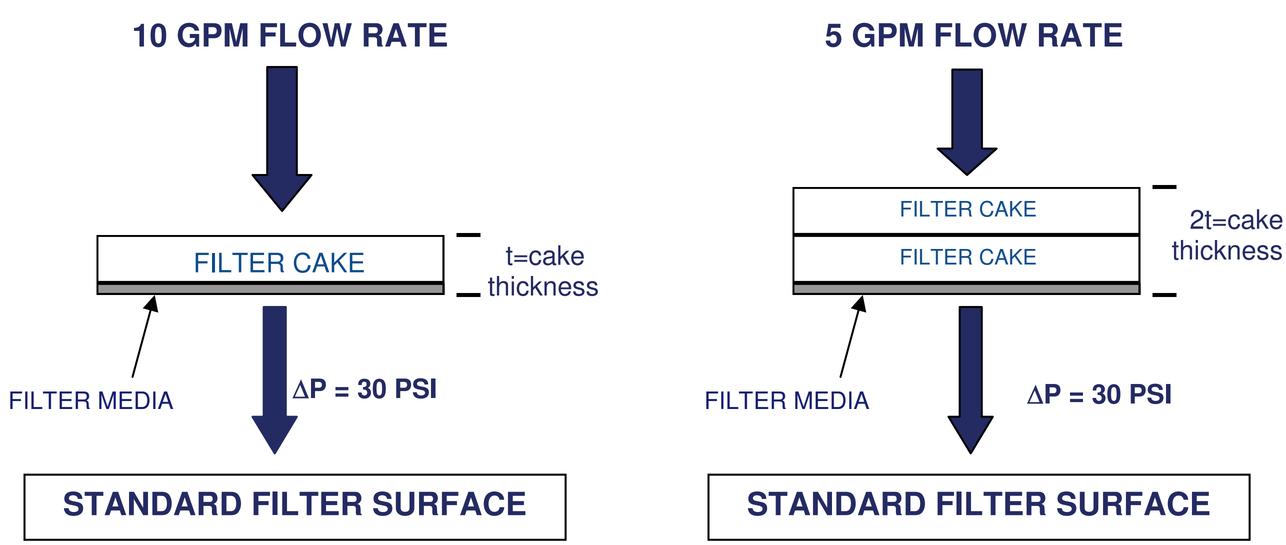
Maximizing filter life by reducing flow rate is usually the most economical way to minimize filtration costs. The flow rate effect is defined by the following formula and is illustrated below.

FILTER LIFE INCREASE =

$$\left(\frac{Le}{Lo}\right) = \left(\frac{Fo}{Fr}\right)^{N}$$

Le = Extended Filter Life
Lo = Original Filter Life
Fr = Reduced Flow Rate
Fo = Original Flow Rate
$0 \le N \le 1$

Cutting the flow rate in half can double the filter life!



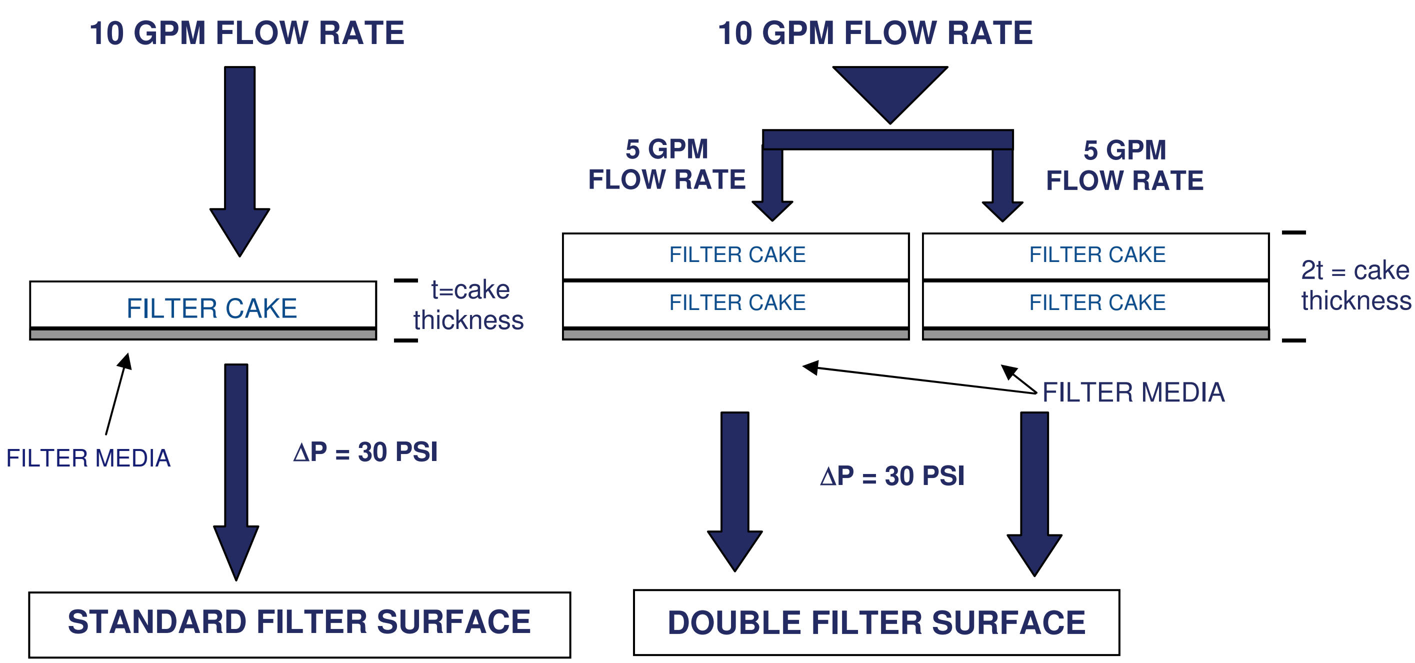
If reducing the flow rate is not a viable option, the alternative approach is to increase filter media surface area. Under a constant flow rate, the life of most absolute rated filters is significantly increased when their effective surface areas are increased. This property of filter life is a direct result of the relationship between flow density and the resulting differential pressure across the filter area.

The surface area effect is defined by the following formula and is illustrated below.

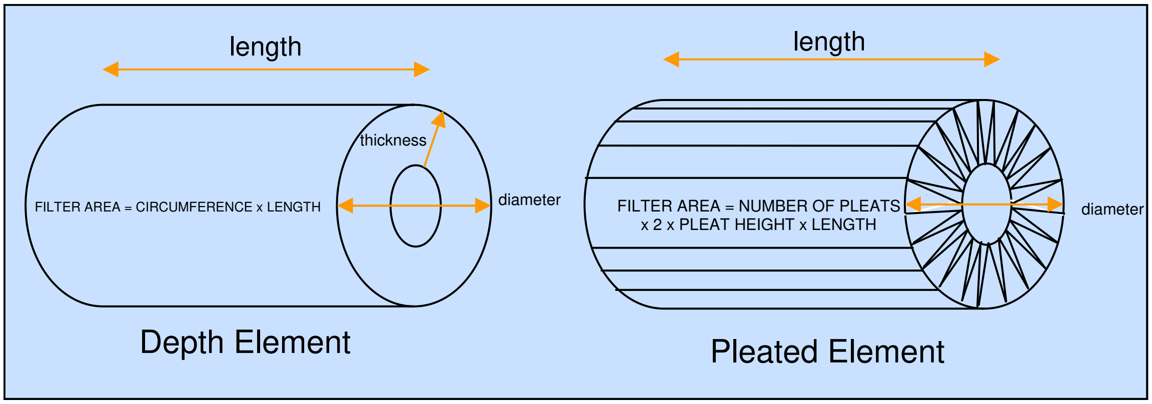
$$\text{FILTER LIFE INCREASE} = \left(\frac{Le}{Lo}\right) = \left(\frac{Ae}{Ao}\right)^{N}$$

Le = Extended Filter Life
Lo = Original Filter Life
Ae = Expanded Filter Area
Ao = Original Filter Area
$1 \leq N \leq 2$

Doubling the effective filter surface area can increase filter life up to four times!

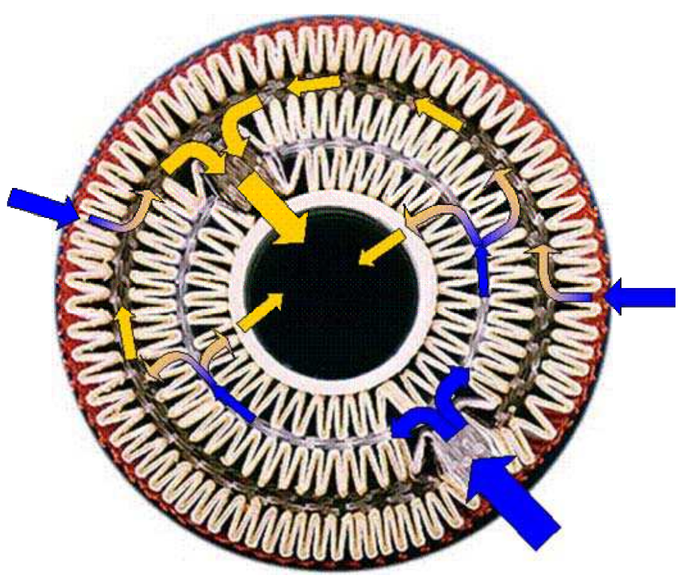


An easy way to increase filter life using an existing housing is to replace depth filters with pleated filters. As shown in the following diagrams, the surface area of the pleated element is more than six times the surface area of the cylindrical depth element.



New Technology Affects Filter Selection

In state-of-the-art filtration systems, large diameter pleated filter cartridges are replacing standard cartridges and non-pleated bags. One design of these larger cartridges utilizes a series of segregated flow channels and flow chambers to maximize the effective surface area of the pleated filter media within each cartridge. The cross sectional view shown below details this basic design which works with either an “outside in” or an “inside out” flow path and is not limited to three rows of media.



FLOW PATTERN

Depending upon the flow rate and contaminant loading, these systems will use one of the following cartridges:

- **6.25” O.D.** **High Capacity Filter (HCF)**
- **12.75” O.D.** **Ultra High Capacity Filter (UHCF)**
- **20.0” O.D.** **Ultimate Capacity Filter (UCF)**

Minimizing Filtration Costs

Filtration Cost Efficiency (E) is defined as the total costs, direct and indirect, that are associated with removing one pound of solids from a process stream. Direct cost is filter price and indirect costs include labor and disposal. The lowest “E” value represents the lowest total cost of filtration. If we disregard equipment depreciation, we can express this relationship by the following formula:

$$E = \frac{P}{H} + \frac{L}{H} + \frac{D}{H}$$

D = Disposal Cost/Filter
H = Dirt Holding Capacity in Pounds
L = Labor Cost/Filter
P = Filter Element Price

Filter price and dirt holding capacity are the dominant components in operating cost. The relationship between these two items is defined by the following formula as the Alpha Factor (Å).

$$\text{ALHA FACTOR (Å) =} \frac{\text{FILTER ELEMENT PRICE (P)}}{\text{DIRT HOLDING CAPACITY (H)}}$$

Combining the Alpha Factor formula with the Filtration Cost Efficiency formula provides an interesting result.

$$E = \text{Å} + \frac{L}{H} + \frac{D}{H} \Rightarrow E = \text{Å} + \frac{L + D}{H}$$

The indirect costs shown in the equation are reduced as the dirt holding capacity of the filter increases. Therefore, the Alpha Factor becomes the dominant number in the equation. The lowest Alpha Factor results in the lowest filtration cost.

Typical Data For 20 Micron Polypropylene Cartridge			
Cartridge Type	**Dirt Holding Capacity**	**Typical Cost**	**Alpha Factor**
String Wound (2.5" OD)	**0.4 Pounds**	**$9.00**	**22.5**
Pleated Absolute (2.5" OD)	**2.0 Pounds**	**$40.00**	**20.0**
HCF (6.25" OD)	**19 Pounds**	**$282.00**	**14.8**
UHCF (12.75" OD)	**85 Pounds**	**$1,044.00**	**12.3**
UCF (20.0" OD)	**255 Pounds**	**$3,065.00**	**12.0**

The Economics of Filtration

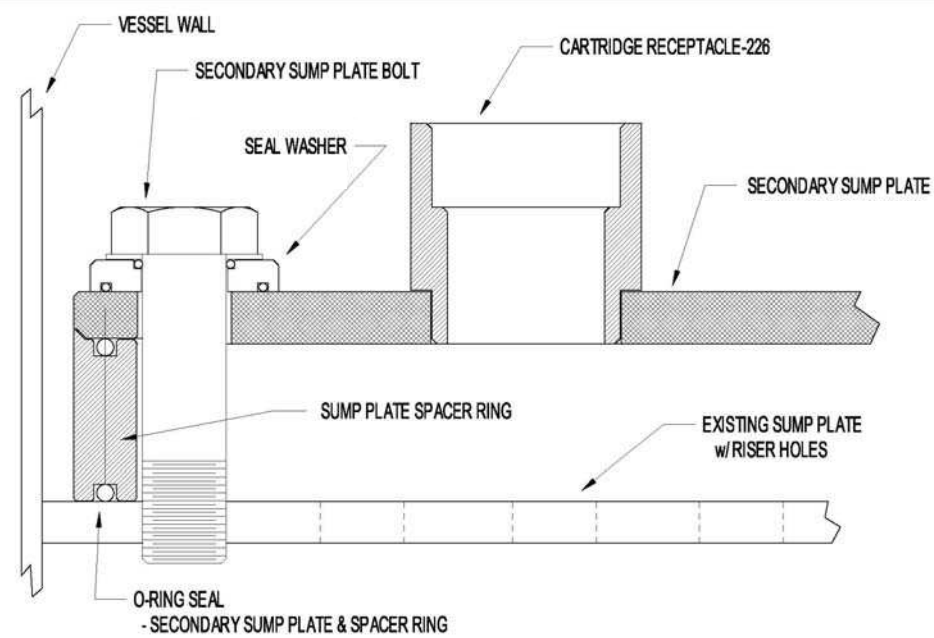
The following exercise shows how cost savings can be realized by these principles to any filtration operation.

MONTHLY OPERATING PARAMETERS				
Parameters	**2-1/2" OD String Wound**	**2-1/2"OD Pleated Filter**	**HCF (6.25" OD)**	**UHCF (12.75" OD)**
Filter Quantity	120	120	19	5
Filter Price	$9.00	$40.00	$282.00	$1,044.00
Pounds of Dirt per Filter	0.4	2.0	19.0	85.0
Change Outs per Month	1.5	0.3	0.2	0.17
Change Out Time (Hrs)	4 Hours	4 Hours	2 Hours	1 Hour
Labor Cost per Hour	$25.00/hr	$25.00/hr	$25.00/hr	$25.00/hr
Disposal Cost per Filter	$4.00/ea	$4.00/ea	$25.00/ea	$105.00/ea

MONTHLY OPERATING COSTS (36” ID Vessel, Contaminate Load 72 Pounds per Month)				
Parameters	**2-1/2” OD String Wound**	**2-1/2”OD Pleated Filter**	**HCF (6.25” OD)**	**UHCF (12.75” OD)**
Filter Cost	$1,620.00	$1,440.00	$1,072.00	$887.00
Labor Cost	$150.00	$30.00	$10.00	$4.00
Disposal Cost	$720.00	$144.00	$95.00	$89.00
Total Cost	**$2,490.00**	**$1,614.00**	**$1,177.00**	**$980.00**
Alpha Factor (Å)	22.5	20.0	14.8	12.3

Vessel Cost Considerations

In most cases, existing filter vessels can be easily modified to accept the large diameter cartridges. The following drawing shows how an existing housing can be refitted with a secondary sump plate to maximize effective filter surface area.



SECTION VIEW - SUMP PLATE INSTALLATION

In new installations capital costs for filter housings are a major consideration. Many plant engineers design their filtration systems based on a maximum flow rate. If a 2.5” OD cartridge is used in the base flow rate calculations, a larger vessel will be required to meet the maximum flow requirements. Utilizing large diameter cartridges in their design parameters, engineers can minimize the filter vessel size required for specific flow rates. This can result in significant cost reductions, particularly when high-pressure filter vessels are required.

With an increasing demand for more cost effective filtration, these new large diameter filter cartridges provide an excellent opportunity for reducing filtration costs in existing and future operations.

Maximum Number of Cartridges Per Vessel ID				
Vessel I.D.	2.5” OD Standard Cartridge	6.25” OD HCF Cartridge	12.75” OD UHCF Cartridge	20.0” OD UCF Cartridge
15”	19	3	1	0
22”	40	7	1	1
28”	70	12	3	1
36”	120	19	5	1