DUTCH FILTRATION

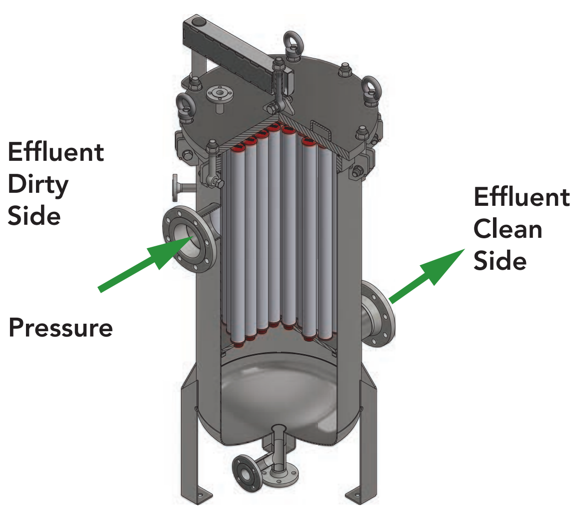
FILTRATION
BASICS OF FILTRATION

WHY FILTRATION

REMOVAL OF FLUID CONTAMINATION

In any manufacturing process the end product is the completion of many steps, each potentially creating difficulties. A properly designed filter system can eliminate many costly problems. The removal of contaminants from a fluid process stream makes that fluid more valuable and increases product yields. A dirty fluid stream in a manufacturing process can decrease productivity and lead to high rejection rates. A filter placed in a strategic location can alleviate such problems and also act as a monitor for the whole process. For example, a filter that plugs prematurely for no apparent reason suggests that there are improper conditions somewhere in the process.

Cartridge filters can be used to protect critical instruments or orifices located in a manufacturing process (i.e. anextruder) so that the instruments cannot break or openings do not become clogged and cause downtime. If the fluid in question is recirculating, reclaim value can also be increased by placing a cartridge filter in line. Removing a haze or classifying particles are other reasons for using cartridge filters. Properly dispersing a mixture, such as pigment/ resin mixture, is an example of this. Finally, since gases are fluids, the removal of aerosols or mists can be achieved with cartridge filters known as coalescers. Vapors can be removed with activated carbon cartridges.



COLLECTION OF SUSPENDED SOLIDS

In the previous section, fluid is described as a valuable asset requiring polishing filtration. In other applications, the suspended solid may be the valuable asset that is reclaimed by cartridge filtration. Many chemical processes require the use of catalysts in order to be functional. Cartridge filtration can recover the unused portions of the catalyst so that it can be used over again. If the catalyst is a precious metal, or if a precious metal is used in the actual reaction cartridge filtration can recover unused portions and thus reduce operating costs.

In the case of pollution control,contaminant needs to be recovered from waste effluents before the fluid is released into the environment, and this can be accomplished by cartridge filtration.

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CARTRIDGE FILTRATION OR SEPARATION

FILTRATION

Filtration is the removal of a suspended particle from a fluid, liquid or gas, by passing the fluid through a porous or semipermeable medium.Finally, since gases are fluids, the removal of aerosols or mists can be achieved with cartridge filters known as coalescers. Vapors can be removed with activated carbon cartridges.

SEPARATION

Separation is the removal of a dissolved substance (solute) from a carrier fluid stream (solvent).

Cartridge filtration is typically pressure driven. Other types of filtration and separation devics may employ alternative driving forces: gravitational settling, centrifugal force, a vacuum, etc.

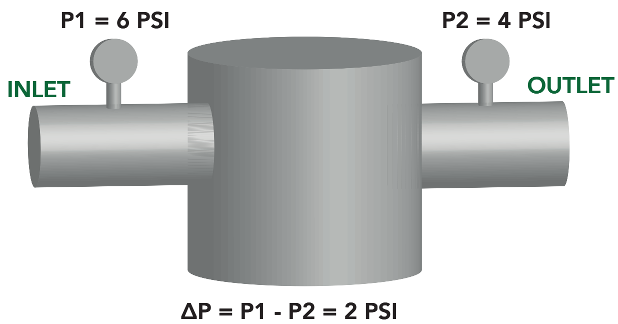
There are several advantages associated with using pressure as the driving force in a cartridge filtration system:

1) Greater output per unit area
2) Smaller equipment than when using other driving forces (consider settling ponds and deep bed filters)
3) Ease of handling volatile liquids

PRESSURE

PRESSURE DROP

There must be a difference in pressure between the upstream and downstream sides of a filter in order to push a liquid through the filter. This pressure differential is largely influenced by the resistance to flow of the filter or medium. The pressure differential is the difference in pounds per square inch (PSI) or kPa between the inlet and outlet ports. Pressure differential may be referred to as PSID, ΔP, pressure drop, or differential pressure.



SYSTEM PRESSURE DROP

The actual system pressure drop (difference in pressure between the inlet and the outlet) is due to loss of PSI, resulting from loss of flow through the cartridge and loss of flow through the housing. Both losses contribute to total ΔP.

*NOTE: Cartridge ΔP increases throughout the filtration process as the cartridge collects dirt and becomes more resistant to flow. Housing ΔP remains constant (assuming constant flow rate and fluid density).

Total System Pressure Drop

ΔP = ΔP Cartridge + ΔP Housing

CARTRIDGE PRESSURE DROP

Fluid flows through channels created by pores in the filter medium. This is called laminar flow, moving in orderly layers, rather than in a turbulent manner. During laminar flow, pressure loss resulting from flow through the cartridge is dependent upon:

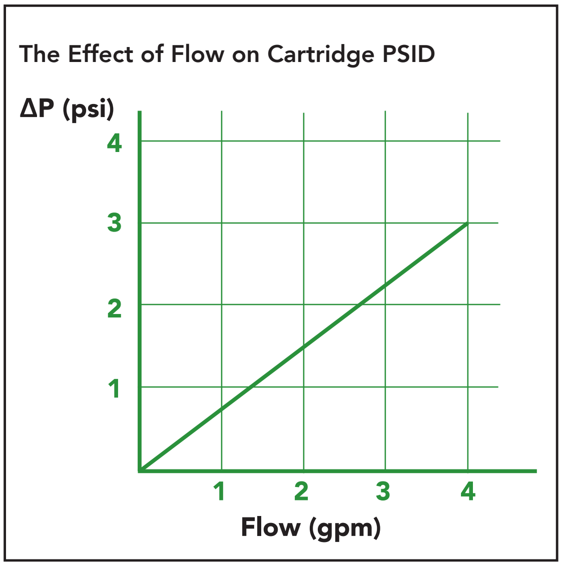
1. Micron rating
2. Viscosity (centipoise-cPs, centistokes-cSt, second saybolt Universal-SSU)
3. Flow rate (gallons per minute-gpm)

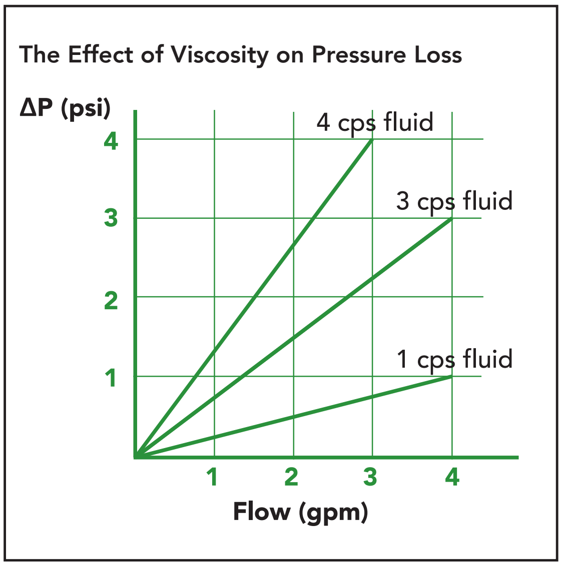
Change in pressure drop can be calculated with the following equation:

$\Delta P = AuQ$

Where:

ΔP	= Pressure drop
A	= Cartridge (laminar) flow constant
u	= Viscosity (cps)
Q	= Flow rate (gpm)





** NOTE: As flow rate and viscosity increase, cartridge ΔP increases.*

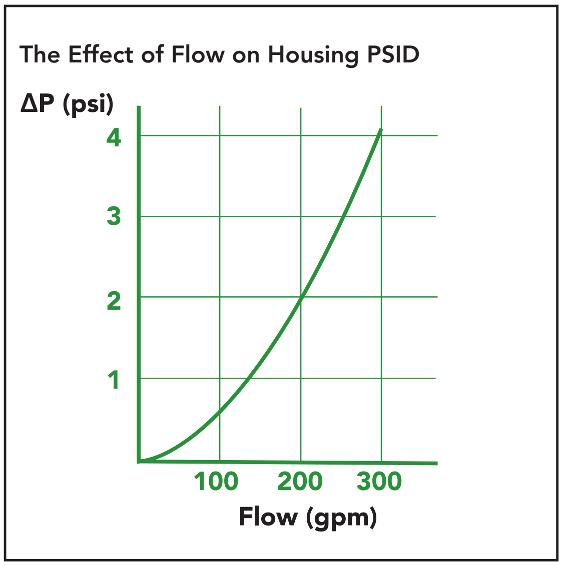
HOUSING PRESSURE DROP

All flow in a housing must pass through the same inlet and outlet port restrictions, which represent only a few square inches in area. Flow through the cartridge filters may be divided among several square feet of area. Thus, the flow rate per unit area through filter housing ports is typically higher than the flow rate per unit area through cartridge media. This high flow rate produces turbulent flow in the housing as fluid disperses through the inlet port or seat cups and into the less restrictive housing cavities. Housing pressure drop increases as flow rate and/or fluid density increase but decrease as port size and the number of seat cups increase (seat cups/ plates hold column of cartridges).

Housing pressure drop is affected by four main variables:

1. Flow rate
2. Fluid density, expressed as specific gravity
3. Inlet and outlet port sizes
4. Number of seat cups (seat plate) in the separator plate

** NOTE: Housing ΔP may become significant at higher flows, such as when used with pleated cartridges.*



** NOTE: How quickly housing pressure drop increases with increasing flow rates.*

CONFIGURATIONS

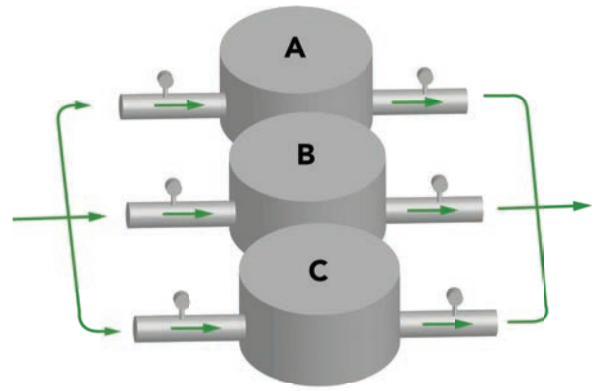
OPEN, PARALLEL AND SERIES FILTRATION SYSTEMS

Filtration systems can be arranged in a number of different configurations or plumbing arrangements. These configurations affect the ΔP of the system. One possible variation is to have an open system, or a system in which the clean effluent is dumped into a tank open to atmospheric pressure. Under these conditions, the total ΔP is equal to the influent pressure, since all system pressure is lost on the downstream side.

Another possible plumbing arrangement is to have two or more systems (housings + cartridges) set up in parallel. In this scenario, the total flow rate will be the sum of the flows of each system. The total ΔP will be the same as the ΔP for each component of the overall setup.

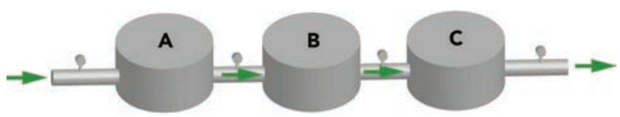
Another configuration is a series filtration system. In this case, coarser prefilters are plumbed in before tighter final filters, producing an accumulative reduction in contaminant levels.

Parallel Filtration



Total Flow rate = Flow Rate A + Flow Rate B + Flow Rate C
ΔPA = ΔPB = ΔPC

Serie Filtration



Total ΔP = ΔPA + ΔPB + ΔPC

** NOTE: The overall ΔP of the series system is also figured by subtracting the effluent pressure from the influent pressure.*

SCOPE OF CARTRIDGE FILTRATION

PARTICLE SIZE RANGE

The size of particles removed by cartridge filtration is defined by the term micron. A micron is defined as one millionth of a meter in length.

Micron = μm =
1/1,000,000 m = 1 x 10-6 m

Some common particle sizes are listed to the right. Visible particles are greater than 40 μm. Haze is caused by 15-20 μm particles.

Contaminant particle size in a fluid is an important consideration when choosing a filtration system. Cartridge filtration is typically used for contaminants in the 0.006-250 μm range.

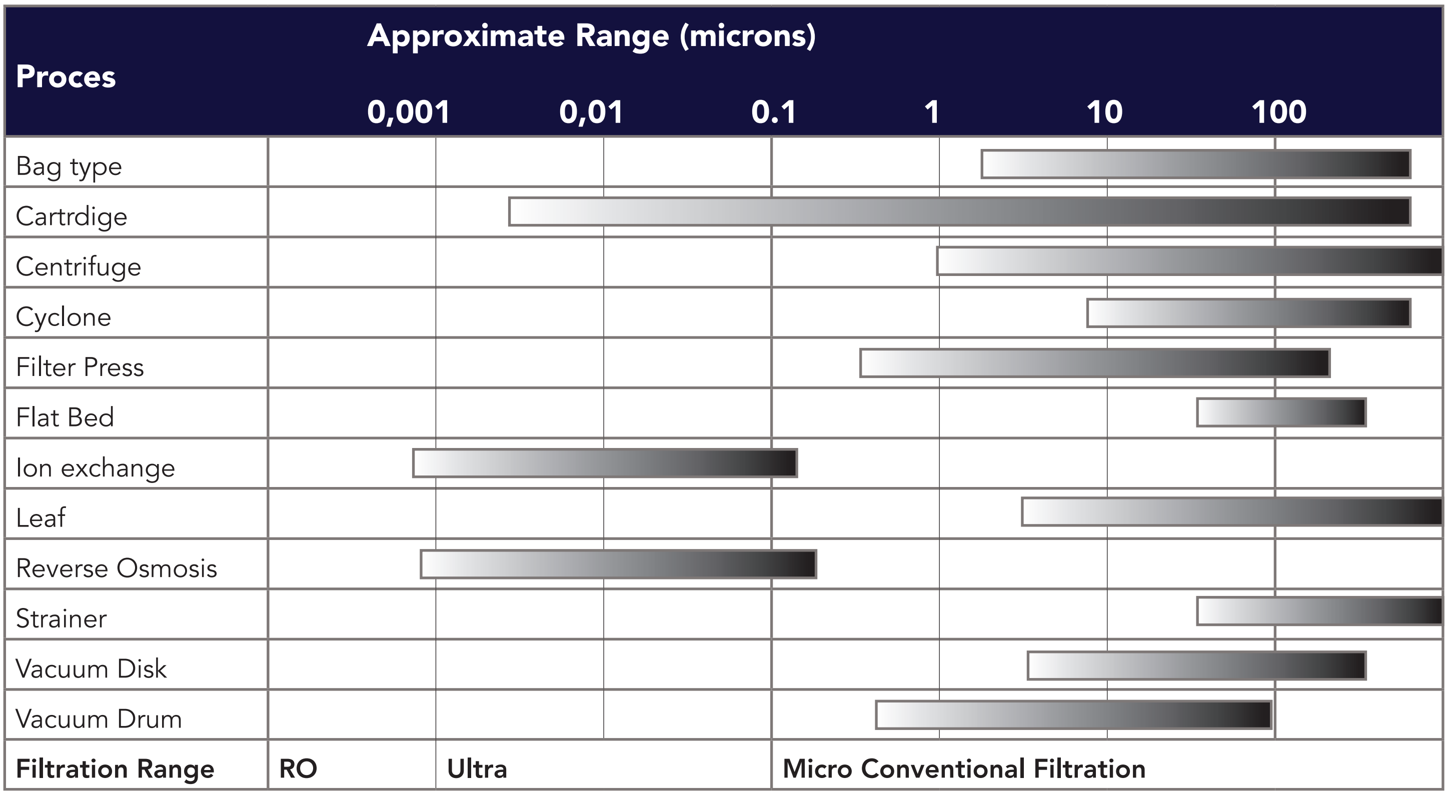
Common Particles Sizes

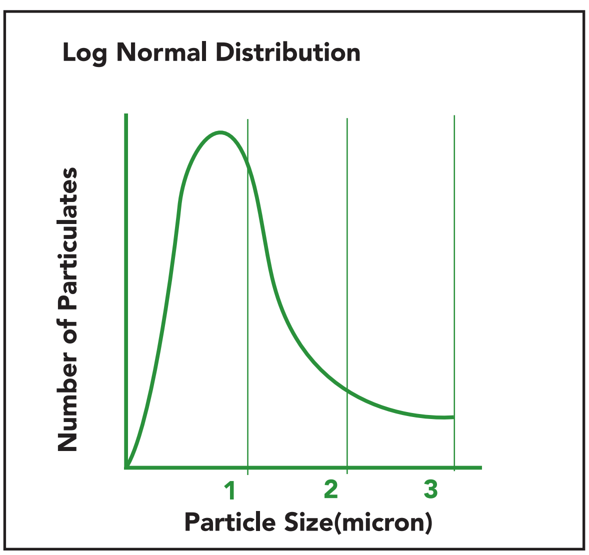
Particle	Size
Table salt	100 micron
Human hair	70 -100 micron
Talcum powder	10 micron
Smoke	1 micron
Dust mites and allergens	0,1 - 0,3 micron

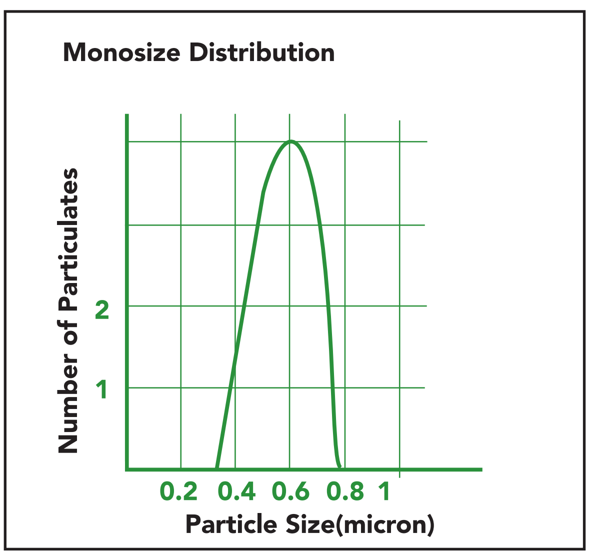
The chart opposite illustrates alternative means of filtration and their removal ranges. The range of particle sizes within a fluid also directly influences which type of filter is used. The actual range of particle sizes can vary tremendously even if the contaminant falls into the appropriate realm for cartridge filtration. The graphs to the left represent the two extremes. The first graph represents a "log normal distribution", typical of nature, in which there is a very broad particle size distribution. The second graph represents a "monosize distribution" in which there is a very narrow particle size distribution. A "monosize distribution" may be found in settings where there is a particular contaminant to be removed (i.e. a specific bacterium) or there is a distinct particle that is not meant to be removed (i.e. pigment), but which comprises most of the particulate population.

The degree of similarity that a contaminant has to either extreme (a log normal distribution or a monosize distribution) will influence the selection of a surface filter versus a depth filter. A surface filter is more appropriate for contaminant that is more monosize in nature. As contaminant becomes more widely distributed in terms of size, one would lean toward a depth filter.

Surface versus depth filtration will be discussed more fully in later sections.







CONTAMINATION Particle Size Range

CONCENTRATION

The level or amount of contaminant contained in a fluid is expressed as parts per million or simply PPM. This term refers to the contaminant fraction of a fluid/contaminant mixture. Cartridge filtration is typically used for contaminant levels in the range of < 1 - 100 ppm (0.0001% - 0.01%) for continuous flow applications and up to 1000 ppm (0.1%) for limited volume batch operations. The chart below illustrates alternative filtration techniques for a wide range of contaminant loads.

** NOTE: Cartridge filtration can be used as a polishing step after other methods have been employed.*

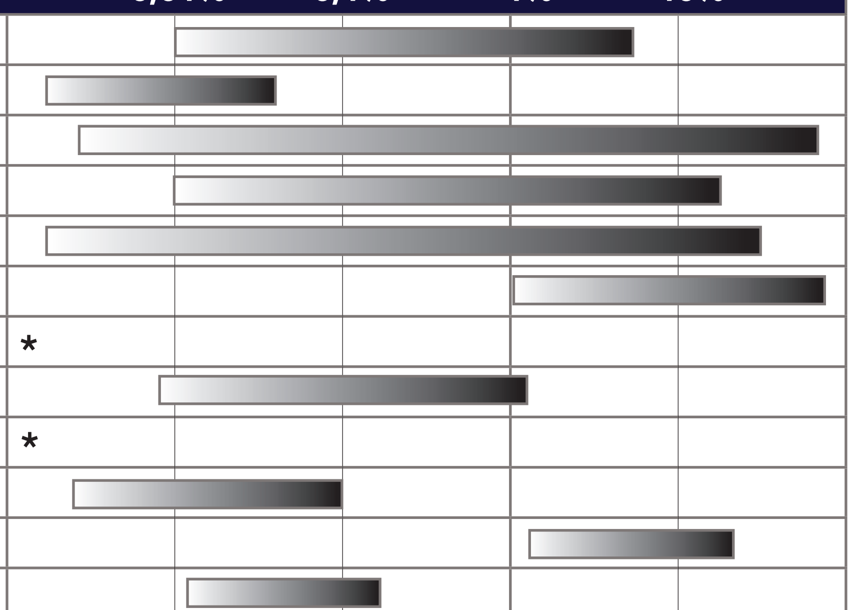
TYPE OF PARTICLE

Filtration removes many different types of particles, each affecting the process in its own way. Non-living contaminants include particles such as precipitates, rust, scale, dust, dirt, fibers, wear particles, minerals, sand and agglomerates of other substances.
Rigid, irregularly shaped particles such as dirt are the easiest to remove by filtration. They will not deform and slip through pores as will gels. They will also form rigid filter cakes that prolong the life of a surface filter. Nonliving particles, however, may also include deformables (i.e. nondissolved resins).

Living particles, with the exception of some plant materials, tend to be irregular in shape and somewhat deformable. Particles in this category include bacteria, yeast, mold, etc. Depth filters are usually recommended for this purpose. However, if the particles are in the submicron range, asymmetric membrane cartridges allow for considerable adsorptive retention, with a very tight mechanical backup layer. (Adsorptive versus mechanical retention is discussed in the next section.) Colloids are unique particles which are usually 0.1 microns or smaller and contain charges, thereby repelling similarly charged particles. In addition, due to their small size, colloids are affected by the movement of the molecules of the liquid medium in which they are suspended. Colloids are often aggregated by the use of a flocculent, a material that neutralizes the charged particles and allows them to clump together. The aggregate,
referred to as a floc, can then settle. In summary, the type of particle being removed influences the means of removal.

Particle Type	Filter Type
Rigid Particles	Pleated Surface Filter
Deformable Particles	Depth Filter
Colloids in Supsension	Membrane Filter

Process	Contaminant Level % Solids in Feed: 0,01% — 0,1% — 1% — 10%
Bag type	
Cartrdige	
Centrifuge	
Cyclone	
Filter Press	
Flat Bed	
Ion exchange	*
Leaf	
Reverse Osmosis	*
Strainer	
Vacuum Disk	
Vacuum Drum	
Filtration Range	***Use Prefiltration first**

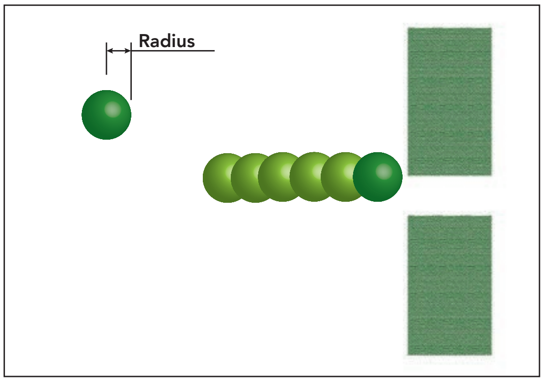


DIFFERENT WAYS OF CAPTURE

There are at least seven mechanisms by which a filter can capture particles. All of these mechanisms are at work in a filter at any given time to varying degrees and may change as operating conditions change. The seven mechanisms of particle capture are listed below.

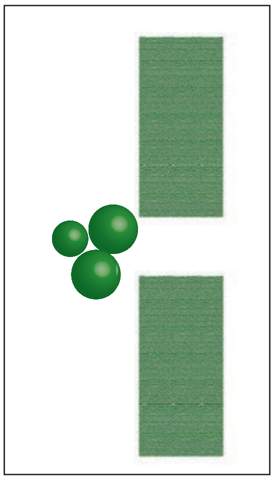
DIRECT INTERCEPTION

Direct interception is usually the governing mechanism in liquid filtration. Interception of a particle occurs by this method when a particle approaches a media obstruction at a distance equal to or less than the particle radius. In essence, if the particle "runs into" a physical barrier, it becomes captured.



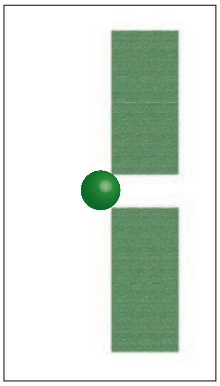
BRIDGING

One single particle may be too small to be directly intercepted or blocked by the filter medium. However, two particles hitting the obstruction at the same time may stick together and be deposited. Particles form a bridge across a pore by hitting the pore simultaneously, or by adhering to each other earlier in the process and then becoming deposited. Bridged particles may not clog the opening completely, thus creating a smaller pore that is more difficult to pass through. The gradual accumulation of particles on the filter medium is known as the formation of a filter cake. This cake creates a finer matrix for subsequent bn interception.



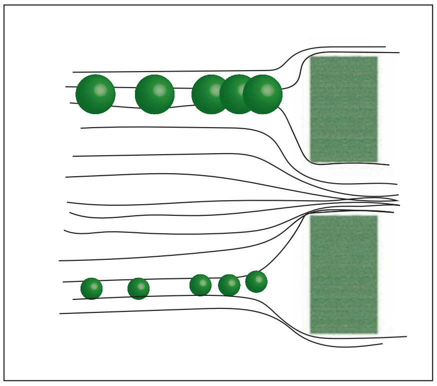
SIEVING

Similar to bridging, sieving is a specialized case of direct interception. Sieving occurs when the opening or pore in the medium is more constrictive than the diameter of the particle. The particle is simply too large to pass through the pore. Sieving may occur on the surface of the filter or throughout the depth of the medium.



INERTIAL IMPACTION

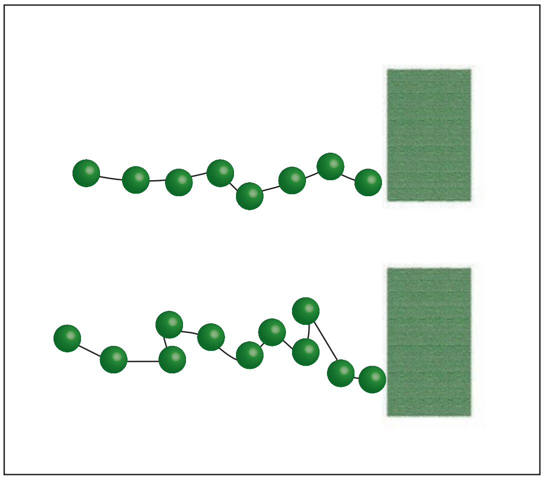
Inertial impaction is based on the scientific principle of inertia, stating that a moving object will continue to move in a straight line unless acted on by an outside force. As particles flow through a filter, they may encounter an obstruction and become captured while the fluid flows around the barrier. Due to the inertia of the particle, it continues to move in a straight line and becomes impacted. Fluid viscosity also greatly affects inertial impaction. Fluids that are highly viscous exert greater drag on particles, reducing the chances of inertial impaction.



Gases, on the other hand, have extremely low viscosity, enhancing inertial impaction to the point of being a primary mechanism of capture in gas filtration.

DIFFUSION INTERCEPTION

The mechanism of diffusion interception is attributable to the fact that molecules are in constant random motion. This motion enhances the opportunity for a particle to become intercepted by the filter medium. Diffusion interception is more prevalent in particles that are 0.1 to 0.3 microns in size, since small particles are most affected by molecular bombardment. Diffusion interception is primarily found in gases due to their inherently low viscosity and high degree of molecular mobility.

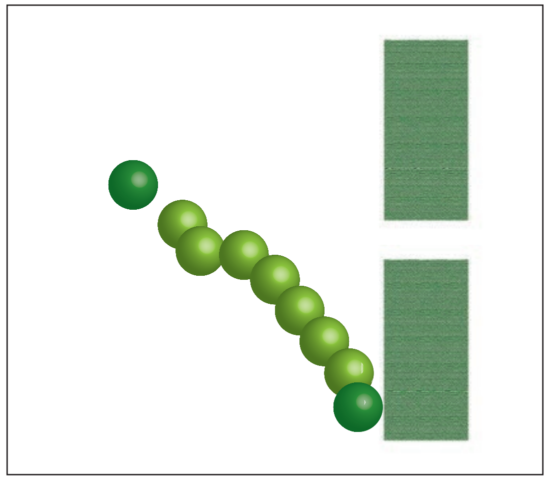


ELECTROKINETIC EFFECTS

Electrical charges may be present on the filter medium and/or on the particles. Particle deposition can occur due to attractive forces between charges or induced forces due to the proximity of the particle to the medium. Some manufacturers purposely alter the surface of the filter medium to enhance electrokinetic capture.

GRAVITATIONAL SETTLING

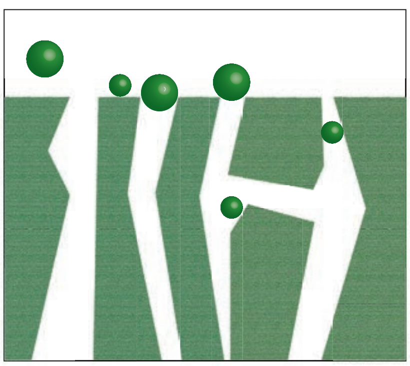
Particles have mass and are therefore affected by gravity. It is possible that a particle may leave the fluid streamlines and settle in the same fashion as sediment in a settling tank. Particles may be deposited within a filter medium or in the up-stream chamber of a filter housing.



MEANS OF RETENTION

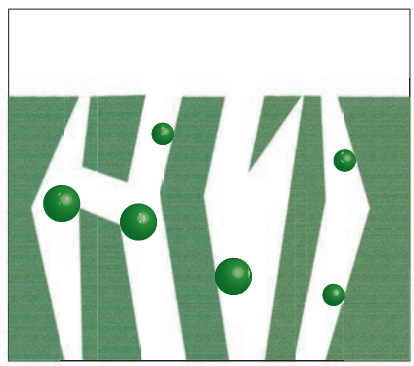
MECHANICAL RETENTION

Mechanical retention occurs when a particle is mechanically restricted from passing through the filter medium. Direct interception, sieving, and bridging are mechanisms of capture that facilitate mechanical retention. Of these three methods of capture, sieving is the most dependable under normal forward flow conditions. If a particle is too large to move through a pore, unless the actual physical structure of the filter medium or particle is altered, the particle cannot be pushed through the pore. Particles captured by both bridging and direct interception are mechanically retained, but are more condition dependent than sieving. Pulsing or surging will dislodge a filter cake and/or small particles directly intercepted by media obstructions and, hence, release the mechanically retained particles. However, if operating conditions are stable, particles held by mechanical retention should not be released.



ADSORPTIVE RETENTION

Adsorptive retention refers to the adherence of a particle to the filter medium due to interactions between the particle and the surface of the medium. The particle "sticks" to the filter. Phenomena behind this adsorptive affect include electrical and hydrophobic interactions. Smaller particles adsorb more strongly than larger particles. The tendency of particles to adsorb, however, is very condition dependent; a particle that is adsorbed can be desorbed. Adsorptive retention predominates for particles captured by inertial impaction, diffusion interception, and electrokinetic attraction.



SURFACE VERSUS DEPTH FILTRATION

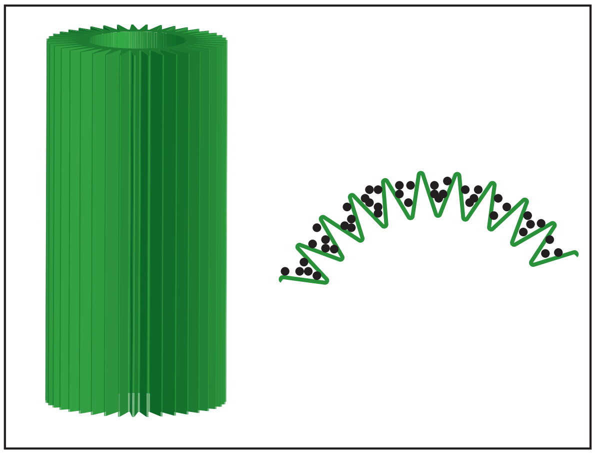
The terms "surface filtration" and "depth filtration" describe parameters of the particle size/pore size relationship present during the filtration process. Although filters are often generalized as being surface or depth filters, in reality, the label is inappropriate unless the particle size/pore size relationship is known.

SURFACE FILTRATION

A true surface filter can be thought of as a screen that is challenged with particles that are too large to pass through its openings. The particles will collect on the surface, forming a filter cake. Retention will be absolute since no particles will be able to penetrate through the surface. This mechanism of capture is recognized as sieving. Note, however, that if the same screen was challenged with small enough particles, it would no longer capture all of the contaminant's at the surface. Hence, the process of surface filtration is strictly dependent upon the particle size/pore size relationship.

SIEVE RETENTION: UNIFORM PORE SIZE

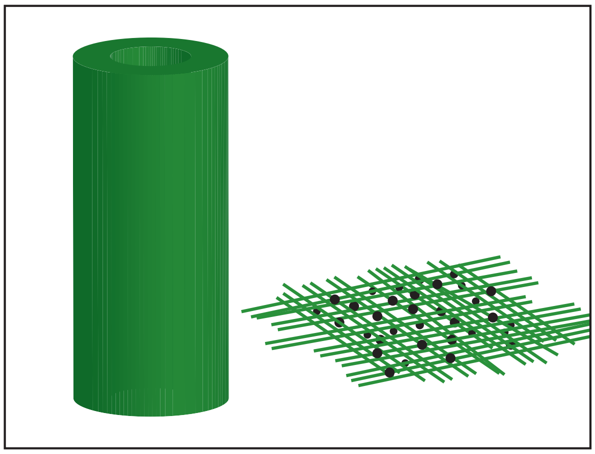
Pleated filters are designed to enhance surface filtration when appropriately utilized. The micro- fiber sheet media has a narrow pore size distribution, favoring absolute sieving, in addition to a large surface area, increasing the capacity to retain particles at the surface. The medium is thin, permitting higher flows with lower pressure drops. These properties promote the formation of a filter cake, giving this type of filter a high dirt holding capacity.



DEPTH FILTRATION

A true depth filter allows particles to penetrate the filter matrix and become captured throughout the depth of the medium. As with surface filtration, this only holds true when the particle size/pore relationship is conducive to the process for which the cartridge was designed.

The depth filter matrix has a broad pore size distribution; hence, depth cartridges rely on adsorptive retention for a portion of their dirt-holding capacity. Some depth filters, such as the ARD, Nexis and DFT Classic, have a gradient pore structure, with tighter pores near the center core, to maximize mechanical retention. In some depth cartridges, such as string wound, the medium is not a fixed pore matrix, as with chemically or thermally affixed pleated media. For this reason, depth cartridges should not be subjected to flows as high as those that are possible for pleated cartridges.



Most depth filters are made from extruded melt blown fibers or twisted yarn fibers. Melt blown depth filters are generally made from polypropylene, polyester or nylon and can be made in both absolute and nominal retention ratings. These types of cartridges can be made to filter particles sizes from less than one micron to over 100 microns. Yarn wound cartridges, made with fibrous materials, are often brushed in order to maximize the tortuosity of flow through the filter. They are nominally rated but offer the advantage of being made from a variety of materials.

DEPTH VERSUS SURFACE

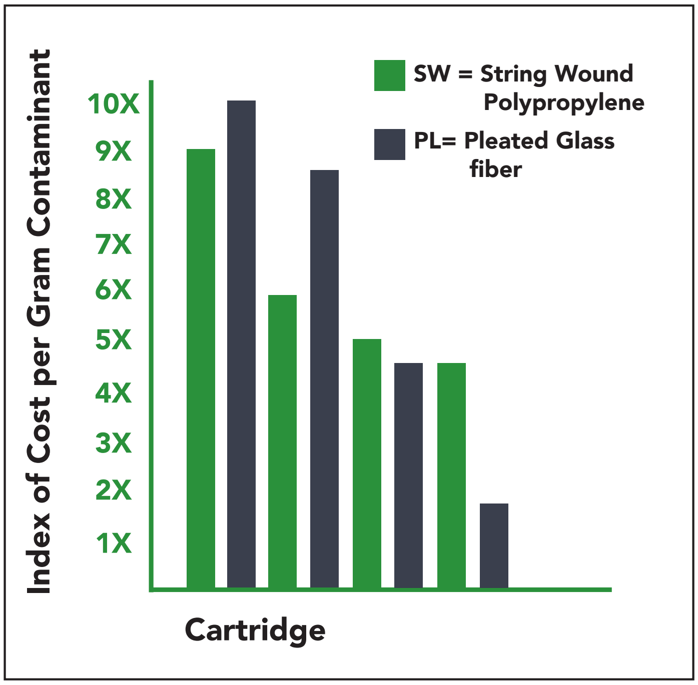
Descriptions of depth filters and surface filters usually emphasize the extreme characteristics of each. In reality, the filtration process is somewhere on a scale between the two, leaning predominantly to one end or the other. The filter chosen to perform the task will dictate whether or not surface filtration or depth filtration will predominate. The debate of depth filter versus surface filter often becomes a complex issue that is dependent upon many different factors.

ECONOMICS

Generally pleated cartridges cost more per 10" equivalent than do depth cartridges. However, at the lower micron ratings, the higher cost of the cartridge is made up by the greater dirt holding capacity. A comparison of cost and dirt holding capacity for wound cotton DFT Classics versus pleated
Duo-Fines was made to determine which is more economical.

COST PER GRAM OF CONTAMINANT

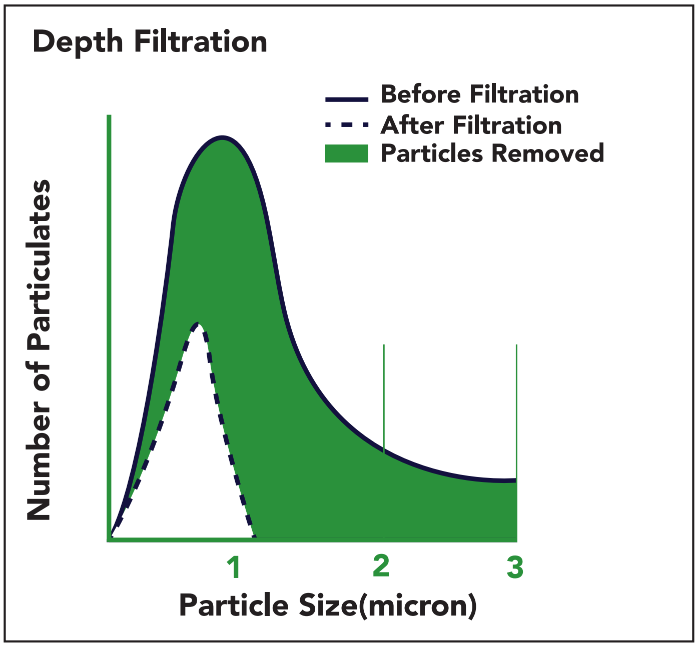
The higher cost per cartridge of the pleated versus the wound levels out between 3 and 10 microns; below this point it becomes more economical to use pleated cartridges. Conversely, above this level, the wound cartridge is likely to be more economical. Keep in mind, however, that direct cartridge to car-



tridge replacement cost is not always the only governing factor. Consider an entirely new application in which a system has to be sized from flow data.
Due to the ability of the pleated cartridge to flow at a higher rate with a lower PSID, fewer pleated cartridges would have to be incorporated into the system. This would require a smaller housing, fewer replacement cartridges and lower disposal costs. In this case, one would have to weigh the difference of the initial cost and cartridge replacement cost.
For example, a 3 micron Duo-Fine costs three times more than a polypropylene DFT but holds 5.2 times the contaminant before reaching change out level.

CLARIFICATION VERSUS CLASSIFICATION

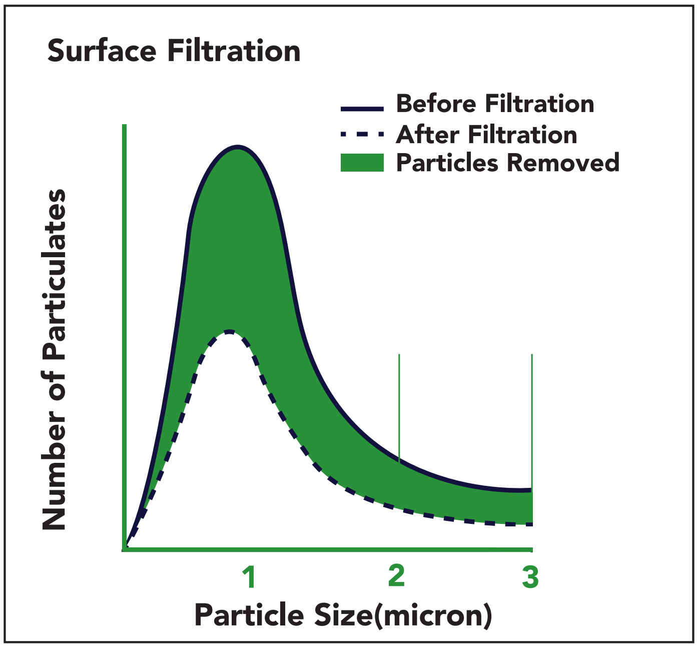
Due to the broad pore size distribution and the nature of removal with a depth cartridge, a broader range of particle sizes can be removed in comparison to removal with a pleated cartridge. The adjacent graph illustrates the performance of a depth cartridge when challenged with a log normal distribution.



** NOTE: Everything above the dotted line was removed.*

This type of removal is referred to as clarification and refers to the removal of a wide range of particles sizes. General removal of a broad range of particles is usually done by depth filters. Due to the narrow pore size distribution of pleated filters, removal is absolute above a specific rating and much less broad (in co parison to depth filters) for particles under that rating. The ideal removal performance for a surface filter is to retain all particles above a specific micron rating while passing all particles below that rating, thereby "classifying" the particles of the fluid. Hence, the term classification is used to describe the filtration performance of a pleated or surface filter.

The surface cartridge illustrated in the graph has a one micron absolute rating. The slight removal of particles under one micron in size is due to the fact that some smaller particles penetrated the depth of the medium and were adsorptively retained or became captured in the filter cake.



** NOTE: Everything above the dotted line was removed.*

FLOW RATES/PRESSURE DROPS

Pleated filters can be subjected to higher flows than depth filters and will have lower initial pressure drops.

If there is a question as to whether depth or pleated cartridges should be used, one could size the system for both and determine which would be more economical.

NOMINAL VERSUS ABSOLUTE

Surface and depth cartridges can be given both absolute and nominal ratings. Membrane cartridges are given absolute ratings. Retention ratings refer to the size of the particles retained rather than the average size of pores in the filter.

There are no industry standards for the assignment of retention ratings and numerical definitions of nominal and absolute differ from company to company. The only way to investigate the true meaning of a nominal or absolute rating is to study the test procedures from the filter manufacturer.

Nominal: A measure of retention, expressed in microns, that specifies the equivalent diameter of the smallest particle for which the filter has a retention of 90% . Other manufacturers may use a different percentage.

Absolute: A measure of retention, expressed in microns, that specifies the equivalent diameter of the smallest particle for which the filter has a retention of 100%. In actual practice, most manufacturers assign absolute ratings on the basis of retention in the range from 98%- 99.999999%.

Recommended Flow Rates		
Cartridge Type	**Recommended Flow**	**Maximum Flow**
Pleated	5 gpm	10 gpm
Membrane	5 gpm	10 gpm
Depth	2.5 gpm	5 gpm

Summary of Surface versus Depth Filters		
Parameter	**Surface Filters**	**Depth Filters**
Deformable Particles	May blind off pleats	Recommended - adsorptive retention
Nondeformable Particles	Removes narrow range	Removes broader range of particles
Rating	Absolute or nominal	Absolute or nominal
Classification/Clarification	Classification	Clarification
Flow per 10” Equivalent PSID	Recommended 10 gpm	Recommended 5 gpm
Economics - Particle Retention < 10 microns	Holds more dirt than depth, handles higher flow rate	More economical than pleated at greater than 10 microns
Cartridge Cost *	More expensive initially than depth,fewer replacements, holds more dirt	More economical initially than pleated, holds less dirt
Housing Cost *	Fewer cartridges - smaller housing	More cartridges - bigger housing

** Based strictly on cartridge purchase, pleated cartridges cost more per 10” equivalent. If a new system is being designed, a larger housing will be necessary for depth cartridges, as opposed to pleated cartridges, to achieve the same flow at a given pressure drop and micron rating.*

FIBER FILTRATION PRINCIPLES

PORE SIZE

Pore size of the filter is the most important consideration when choosing a cartridge. Pore size is dependent upon the following:

Fiber Diameter

As fiber diameter decreases, mean pore size decreases. In other words, in order to get a finer filter, use thinner fibers.

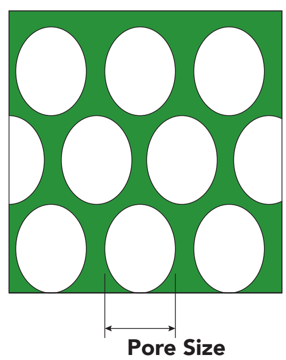
Porosity

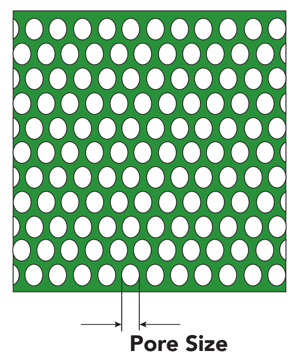
Porosity is the ratio of the void volume to the total volume of a filter medium. Porosity can be decreased by winding a cartridge more tightly.

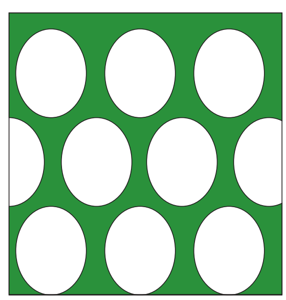
Decreasing the porosity decreases the mean pore size and makes the filter finer. However, decreasing porosity also increases the resistance to flow of the cartridge, consequently increasing the overall ΔP.

Thickness of the Filter Media

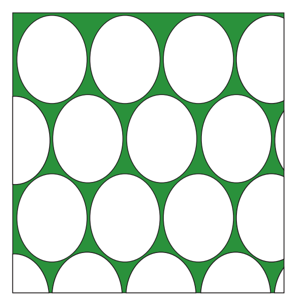
As filter medium becomes thicker, mean pore size decreases and as layers of medium are added to a cartridge, the pores become smaller. However, as is the case with porosity, adding layers to the medium increases the resistance to flow and, consequently, the overall ΔP.







Higher Porosity



Lower Porosity
More Flow Resistance

** NOTE: Designing a fibrous filter is a juggling act between fiber diameter, porosity and thickness of filter medium.*

FILTRATION VARIABLES

Filtration performance (life and efficiency) varies as operating conditions change. The guidelines d scribed below are a basic outline of how operating conditions affect filter life and efficiency.

EFFECT ON EFFICIENCY

1) Flow Rate - High flow rates are detrimental to adsorptive retention mechanisms and, hence, decrease efficiency. This effect is more dramatic in wound cartridges and at higher micron ratings. Conversely, a decrease in flow rates increases efficiency by enhancing adsorptive retention and the ability to form a filter cake. Some evidence suggests that optimum efficiency occurs around 0.5 to 0.75 gpm/1 ft2 for pleated media.

2) Differential Pressure - In order to maintain a constant flow rate through a filter as it plugs with contaminant, more fluid must flow through the progressively smaller unplugged portions of the cartridge. This increases differential pressure and decreases efficiency.

** NOTE: If the differential pressure is allowed to exceed the manufacturer's recommended maximum, typically 35 PSID, both the life and efficiency of the cartridge may be compromised.*

3) Viscosity - Increasing viscosity increases the hydrodynamic drag of the fluid and also increases the differential pressure required to push the liquid through the filter. Increasing the viscous drag is detrimental to adsorptive retention, consequently decreasing filter efficiency.

4) Contaminant - The relationship of particle size distribution to pore size determines the degree of surface versus depth filtration.

5) Flow Conditions - Cartridge filters are designed for use under steady flow conditions. Pulsating flow can disrupt a filter cake and/or dislodge particles that were adsorptively or even mechanically retained. Excessive pulsing can also cause structural damage to the filter.

6) Compatibility - Fluids that are not compatible with a filter can have various detrimental effects on filtration efficiency. Incompatibility can cause filter media to swell, become brittle, dissolve, shrink and separate from end seals and release fibers. The filter may become seriously weakened.

7) Area - Increasing filter area while keeping the flow rate constant reduces the flux or flow density (flow rate per unit area) and, therefore, increases filter efficiency.

EFFECT ON LIFE

1) Flow Rate - Increasing flow rate decreases the life of the filter. Conversely, decreasing flow rate increases the life of the filter. This is largely due to increased bridging of pores near the upstream surface of the filter and premature plugging of the filter medium.

2) Differential Pressure - It is recommended by most manufacturers that filters be changed out at a terminal ΔP value. Filter life can be maximized by starting out with a low initial ΔP, thereby allowing more of a buildup to reach terminal ΔP.

3) Viscosity - Increasing viscosity increases the differential pressure required to push the fluid through a filter. A higher initial PSID means less on-stream life until terminal PSID is reached.

4) Contaminant - If the following conditions are met:
a) a nondeformable, irregularly shaped solid builds a noncompressible cake
b) the filter cake does not become a finer filter than the medium itself and
c) the collected solids are relatively uniform in particle diameter, then cartridge life will be maximized and approach the relationship:

Change In Filter Life =
(Change In Effective Filter Area)^2

5) Flow Conditions - Steady flow conditions promote the accumulation of a filter cake which increases service life. Pulsating conditions can disperse the cake, temporarily lowering PSID until the cake builds up again or prevent the formation of a filter cake at all.

6) Compatibility - Compatibility problems have a detrimental effect on efficiency. If efficiency is seriously affected, filter life is irrelevant.

7) Area - Increasing filter area directly increases filter life, up to a point. Doubling the filter area can increase
filter life up to four times (minimum of two times), but there is a practical limit to the amount of filter media
that can be packed into a cartridge. Beyond this optimum area, diminishing returns in life can be expected. For this reason, comparisons of cartridges made with different media on the basis of area alone can be misleading.

CARTRIDGE FILTER CONFIGURATIONS

Cartridge filters are available in a variety of different configurations. The chart on the following page summarizes different types of cartridge filters and lists examples within the Dutch Filtration product line for each one.

Summary of Variables		
Variable	**Cartridge Efficiency**	**Cartridge Life**
Flow Rate	Decrease flow = increase efficiency	Decrease flow = increase life
Differential Pressure (PSID)	Decrease PSID = increase efficiency	Decrease PSID = increase life
Viscosity	Decrease viscosity = increase efficiency	Decrease viscosity = increase life
Contaminant	Dependent on pore/particle size relationship and contaminant type	Nondeformable particles promote formation of life extending filter cake
Flow conditions	Pulsing/surging is detrimental	Steady flow promotes filter cake formation = longer filter life
Chemical Compatibility	Incompatibility threatens efficiency	Incompatibility threatens life
Area	Increase area = increase efficiency	Increase area = longer life

Overview Consumables Dutch Filtration Part 1			
Brand name	**Filter type**	**Description**	**Benefits**
DutchFlow	Absolute Pleated Depth Filter	Pleated media (glass fiber or polypropylene) with Polypropylene inner core (stainless steel is optional)	Provides signifi cantly greater dirt holding than string wound and spunbonded elements. Full Thermal Bonded technology. Absolute rating of Beta 5000 (99.98% efficiency) for reliable results in any critical application
FiberFlow QA	Spunbonded Absolute Filter	Multilayers of fine spunbonded Polypropylen or nylon. Polypropylen inner core is optional.	Large volume of contaminant volume absorption through the multiple separation layers. Brought range of contamination particle size separation ability without plugging. absolute filtration exceeding Beta 1000 (99.9% removal)
FiberFlow QN	Spunbonded Nominal Filter	Multilayers of fine spunbonded Polypropylen or nylon. Polypropylen inner core is optional	FDA approved polypropylene material. Large volume of contaminant volume absorption through the multiple separation layers.
TwistFlow	Nominal Wound Filter	Multi layers of fine Polypropylene string, precision pattern wound provide both depth and high performance separation.	Brought range of contamination particle size separation ability without plugging. Minimum pressure drop in medium and course size rating.
OilLock	Oil Absorption Filter	Designed and manufactured for the high efficiency removal of free, dispersed and emulsified oil from water.	99% removal of all oils in one single pass. Cartridge blocks after saturation, no pass of hydrocarbons possible. The adsorption capacity is more then 2 liter of hydrocarbons.
BagFlow	Filter bag	Standard needle felt fi lterbags, welded seams, mesh, pleated and multilayer felt with rigid rings or snap ring	Contaminated fl uids flow from inside to outside, so all solids are retained in the bag. Low operational costs. Easy handling, easy, clean and quick change out of filter bags.

Overview Consumables Dutch Filtration	
Brand name	**Typical applications**
DutchFlow	Completion fluids, Produced water, Work over fluids, Gravel pack fluids, Wellbore clean up fluids, (Bio) diesel, Surface water intake, Process water, Pre-filtration RO, Pre-filtration UF, Pre-filtration MF, Frac fluids, Pipeline flushing, Waste water, Re-circulating liquids, Reagent grade chemicals, Make-up and wash waters, Oils and acids, Alkalis, Catalyst recovery, Membrane pre-filtration, Chemical filtration, Resins and emulsions, Inks and paints, Solvent filtration, Liquid clarification, Recirculating liquid, Reagent-grade chemicals, Machine tool lubrication, detergents, process and waste water, plating baths, Pulp & paper and textiles, process fluids, amines, glycols, hydrocarbons, brines, fuels, acids, bases
FiberFlow QA	Fine chemicals, High purity water, Optical coatings, Inks, Chemicals Pharmaceuticals, Paint/Inks, Food and beverages, Water, electronics, Plating, Cosmetics, CMP, Slurry
FiberFlow QN	Completion fluids, Produced water, Work over fluids, Gravel pack fluids, Wellbore clean up fluids, (Bio) diesel, Surface water intake, Process water, Pre-filtration RO, Frac fluids, Pipeline flushing, Waste water, Solvents, Resins, High purity chemicals, Industrial coatings, Solvents, Bulk inks, Chemicals, Water treatment, Solvents, Emulsions, Plating solutions, Pigment slurries, Guard filtration, RO Prefilters, Wastewater, Food and beverages, Chemicals, Blowdown post filter, Aqueous solutions
TwistFlow	Completion fluids, Produced water, Work over fluids, Gravel pack fluids, Wellbore clean up fluids, (Bio) diesel, Surface water intake, Process water, Pre-filtration RO, Frac fluids, Pipeline flushing, Waste water, Plating baths, Phosphate baths, Melt polymer filtration, Chemical, Food & Beverage, Paint & Ink, Utilities, Petrochemical, Plating, cooling water, condensate water, acids prefiltration, process water, alcohols, solvents, refined products, prefiltration, metallisation bath, prefiltration process water, bottled water, cosmetics, plastics, alcohols, ketones, ether, hydrocarbons, paint, varnishes
OilLock	Oily waste water, Mud pit cleaning, Produced water treatment, Clean-up of displacement water, Acids flow back, Completion fluids, Sea water, river water,well water, Decommisioning of old pipe installations, Pipeline system purge, clean up, Hydro test discharges, Balllast and bilge water clean up, Run off water, Water Soluble Machine, Alkaline Parts Washing, Industrial Discharge Water, E-Coat Paint, Post Oil/Water Separator, Compressor Condensate, Car & Truck Wash Water, Plating Bath, Gas & Oil Facility Wastewater, Surface Water Runoff (Truck stops, airports, auto service stations), Pre Carbon Bed, Aerosol Mists Cooling Water, Pre R.O. Membrane Polishing
BagFlow	Completion fluids, Produced water, Work over fluids, Gravel pack fluids, Wellbore clean up fluids, (Bio) diesel, Fuel oil, Sea-, river-, well water intake, Process water, Pre-filtration RO, Acids, Solvents, Amines & glycols, Waste water, Adhesives, Beverages, Bulk Chemicals, Coatings, Coolants, Edible Oils, Inks, Liquid Detergents, Paints, Parts Washing Systems, Petroleum Oils, Prefilters for Finer Cartridges, Resins, Solvents, Water, Lacquers, Varnishes, Waxes, Cutting oils, Acrylics, Automotive, Sugar Processing, Dispersions, Resins, Lubricants and Metalworking Fluids, Aqueous and Solvent Based Cleaners in Parts Washing Equipment, Pulp and Paper, Pharmaceutical, Food Processing, Chemical Process Industries, Potable Water, Beer and Wine,

Overview High Flow Elements Dutch Filtration Part 1			
Brand name	**Filter type**	**Description**	**Benefits**
MaxFlow	High Flow Pleated Filter	Pleated media construction combined with a rigid case construction	Absolute rating of Beta 5000 (99.98% effi ciency) for reliable results in any critical application.
MegaFlow	High Capacity Pleated Filter	Glassfibre and polypropylene. The car-tridges are provided with a standard226 positive o-ring seal and an easy to grip cross handle.	Quick and easy change out with integrat-ed handle. Absolute rating of Beta 5000 (99.98% effi ciency) for reliable results in any critical application.
UltraFlow	High Flow Capacity	Rigid cage construction combined with bayonet end cap	Absolute rating of Beta 5000 (99.98% effi ciency) for reliable results in any critical application. Provides signifi cantly higher dirt holding than normal pleated, longer life
GigaFlow	High Flow Absolute Rated Filter	Pleated glassfiber or Poly-propylene media with posi-tive o-ring seal	High Flow capacity means fewer car-tridges and less time to change out. High surface area pleated design provides low pressure drop and long service life
WellFlow	Absolute Rated High Pres-sure Filter	Pleated cartridge with Stain-less steel core and cap	Heavy duty construction provides up to 50 PSID of allowable differential pressure for high pressure liquid / gas applications. Absolute rated media with fixed pore structure prevents particle unloading and provides reliable results in critical applica-tions.
MaxBag	Pleated filter bag	Pleated bag with replacable flange connection, fits most bag filter housings	Absolute rating of Beta 5000 (99.98% ef-ficiency) for pleated version. Full Thermal Bonded technology offering chemical compatibility for most fluids, solvents, chemicals

Overview High Flow Elements Dutch Filtration Part 2		
Brand name	**Typical applications**	**Replacable for**
MaxFlow	Completion fluids, Produced water, Work over fluids, Gravel pack fluids, Wellbore clean up fluids, (Bio) diesel, Surface water intake, Process water, Pre-filtration RO, Frac fluids, Pipeline flushing, Waste water, Geothermal, Acids, Solvents, Gels Amines and Glycols, Food & Beverage, Power Generation, Speciality Chemicals, Water Treatment, Photochemistry, Hydrocarbons, Brines, Fuels, Coolants, Acids, Bases, Plating Solutions, RO/UF Pre-filtration, Food and beverage, Bottled water, Beers, Wines, Polishing lines, Solvent discharge, Raw water supplies, batch transfers Fine Chemicals, Polymers, Bases, UV protection, Resin trap, Wash solutions, Blanking wash oils, Electrophoretic paints, return condensate lines	Pall Ultipleat, Parker Parmax R,
MegaFlow		3M cuno 740B, 7000
UltraFlow		3M cuno High Flow HF
GigaFlow		Parker MegaFlow Plus (absolute rated)
WellFlow		
MaxBag		