Small System Filtration?

By Matthew Wirth

Whether the water treatment system processes two or two million gallons (7.57 L to 7.57 mL) per day, the end user expects quality water. The same science, chemistry and engineering apply across the entire range of system applications. It is therefore critical that system providers apply sound practices and adhere to manufacturer's operating specifications before placing any system in service.

Filtration applications less than ten gpm (37.85 L/m) are common to most small system applications. These often consist of large particulate strainers, fixed filtration devices and backwashing media filters.

Each has common attributes, unique process applications and limiting factors. To apply these devices, one must understand the physical principles that govern each system's operation.

Strainers

Strainers come in a variety of configurations and types. The purpose of a straining device is to remove large particulates > 50µm (micron). A strainer may consist of a housing body and a screen or a centrifuge designed to use centrifugal force to remove particulates of sufficient weight. Screens are sized in mesh or microns.

This dot (.) is approximately 1/64 of an inch wide and equals 615 microns. There are 25,400 microns in a postage stamp one-inch high. A particle would be approximately 40 µm to be visible to the naked eye.[1]

Another common unit of measure for strainers is mesh. There can be varying definitions of mesh size. A 200-mesh screen will trap a 74-micron particle—the width of a normal human hair. A conversion chart from mesh to microns is available at www.showmegold.org/news/mesh.htm.

Screen strainers only load particulate on their surface. This requires regular flushing of the screen surface to prevent the trapped particulate from plugging the device. Remember, a 200-mesh screen removes sand and debris ≥ 200-mesh (74 micron.)

Sand and debris, once trapped, will begin to act as a secondary filter for smaller particles as it collects on the surface of the strainer's screen. Based on particulate volume, this can greatly accelerate surface loading. While this offers finer filtration, it becomes problematic if it prematurely plugs the system and/or causes excess system pressure loss.

One must be aware of the flow and pressure requirements of any downstream mechanism. Too small a strainer can limit available backwash for media-type systems, booster pumps, etc.

It should be noted that filter screens can act as diffusers and increase the introduction of oxygen into the water stream when free air exists within the water system. This can accelerate iron oxidation by exposing more water to oxygen in air bubbles. Once formed, these iron oxides may plug downstream plumbing.

A type of fixed filter, called a separator, uses centrifugal action to remove suspended solids and sand. The device spins water inside its cylinder to drive particulates of sufficient mass into a collection chamber.

Particulate removal is governed by the laws of physics and gravity. The particle's mass and the velocity (centrifugal force of the system) dictate particulate removal. (The water analysis and manufacturer's specification should be referenced when applying this technology.)

Fixed filtration

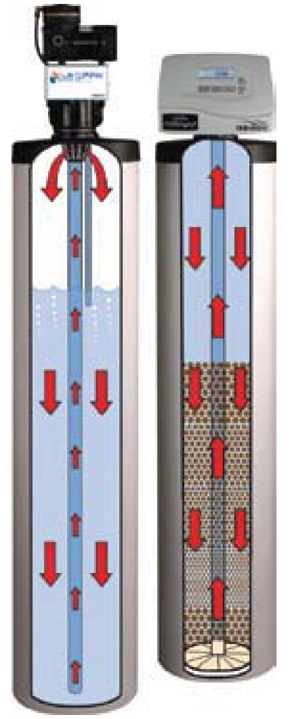
Fixed filtration applications range from simple cartridges and bag filters to micro and ultrafiltration. Fixed filtration refers to a class of filters that do not backwash. The most common type of fixed filtration is the cartridge filter. There are hundreds of different cartridges on the market.

Carefully review the cartridge filter's flow rates and throughput (total gallon capacity of a system) and do not exceed its design capacity. Any quality filter has a published flow rate.

Cartridges designed for contaminant removal must have a throughput. If it does not specify flow and/or throughput, it should not be used, as there is a danger of exceeding its capability.

Microfiltration (MF) technology should be used to remove particle sizes less than 1.0 µm. Ultrafiltration (UF) membrane technology removes finer particles as well as dissolved organics. UF membranes typically have pore sizes in the range of 0.01-0.05 µm. The pore size allows for a high removal capability of bacteria and most colloids and silt.[2]

One common misconception of this membrane technology is its ability to reduce TDS. MF and UF do not reduce TDS. The removal capability is based on the pore size and mineral salts are too small to be rejected by these filters. Due to the pore size and applications common to these devices, microbiological fouling and particulate loading become a service matter. These require frequent flushing and biocide control.



Adsorption media cartridges

Media such as activated carbon utilize adsorption to chemically attract contaminates to the surface. This is a common cartridge application.

Most home RO systems utilize an activated carbon cartridge. It is essential that the media be monitored for servicing and changing prior to contaminate breakthrough.

If the system is intended to remove a health-related contaminant, it is essential that a shut-off/fail-safe device be installed to stop water service once removal capacity is reached. It is advantageous to install a pre-filtration device ahead of an adsorption system to reduce the loading of troublesome particulate on the adsorption media.

Sediment cartridges

Common sediment cartridges come in two basic designs; pleated and depth. Pleated filters appear corrugated. These cartridges load on their surface and pleating allows for greater surface area for loading.

Pleated filters allow manufacturers to closely control the porosity of the filter membrane and this design lends itself well to conforming to absolute filtration requirements. An absolute pore size rating specifies that a particular size will be retained with 99 percent efficiency under strictly defined test conditions. A one-micron absolute filter ensures that the filter will not pass particles ≥ one µm.

Depth filters are made of a material that allows porosity throughout; i.e., polypropylene, which allows particulate penetration into its depth. The filter becomes tighter as water pressure increases. This type of filter provides increased loading and therefore, longer throughputs.

They usually come in a nominal rating rather than an absolute rating. A nominal pore size rating provides 85 percent particulate removal to that size; e.g., a one-µm (one-micron) nominal rated filter removes 85 percent of the particles one µm or larger.

Because flow and pressure loss associated with fixed filtration varies as the filter loads, this can become problematic to systems that are pressure and flow sensitive. For applications requiring simple particulate removal, the best practice for monitoring these filters is pressure loss.

Pressure drop

A pressure gauge should be installed on the inlet and outlet of the filter housing to track the ΔP (Delta P). This is the pressure drop or the difference between the inlet and outlet water pressure during water flow through a water treatment appliance such as a multi-media filter or water conditioner.

The ΔP will increase as the filter loads. By knowing the acceptable ΔP for downstream systems and/or the ΔP acceptable for filters, one can accurately determine the frequency for changing and servicing the fixed-filtration device.

Smaller fixed-filtration devices work well for single-faucet POU applications, clarifying water with minimal suspended solids. But they are not ideal for POE applications servicing an entire facility's daily water usage.

In the field, it is not uncommon to find a cartridge filter capable of only five gpm installed before a media filter needing eight to 12 gpm (30.28 to 45.42 L/m) for proper backwash. This commonly occurs because the filter is installed by the well driller when the system is new and prior to the filter's placement. It is a good practice to inspect upstream plumbing before installing any new filtration device.

Be aware that maximum published flow rates are not for prolonged flow events, but for short intermittent peaks. It is suggested that the operating conditions be checked before using it in a system. Bag filters and multi-cartridge systems are commonly used in systems needing higher flow rates, such as commercial and industrial applications.

Media beds

Media beds are commonly found in pressure vessels with automatic or manual controls that allow the filter to backwash and clear itself of particulate loading. A media filter acts as a mechanical straining device designed to trap suspended solids floating free in the water supplies.

In service, water cascades down through the media bed (loose granules of special sands and/or manufactured material). This allows suspended particulates to be removed as water progresses through the filter and out to service.

Backwash is a process where flow through the filter is reversed and water pushes up through the media bed. This stratifies and expands media granules in the vessel to allow trapped matter to exit the vessel out of the top through the control valve.

As media granules stratify, they collide with each other to dislodge clinging matter. In this manner, the filter processes water while removing solids and then flushes the solids out to the drain.

Media beds also act as mechanical straining sieves for removing oxides. In applications such as iron filtration, ferrous iron (Fe^{++}) in solution is exposed to oxygen and oxidizes to form a suspended ferric iron (Fe^{+++}) particulate.

Ferric particulate attracts other like particulates to form soft, gelatin-like ferric oxide/hydroxide flocks—envision an iron snowflake. The filter removes the soft iron flocks as they settle on the surface of the media bed. As they collect, they form an iron cake on top of the media bed, adding to the straining process.

Most filter media allow some bed penetration to prolong service runs. In a single medium filter, the finer grains of media migrate to the top of the filter bed. It traps most undesired particulates in the void spaces of the media bed's top four to six inches, but unfortunately this leaves much of the bed unused and increases the need for backwash.

Multi-layer vertical filtration

A common method used to prolong service runs between backwashes is multi-layer (multi-media) vertical filtration. Larger, coarse media layers on top with two or three gradually finer media layers following in progression.

For the different media types to layer, they must have different specific gravities (relative density). The coarse top layer's specific gravity must be lower than the subsequent layer.

As an example, the specific gravity of a coarse filter Ag is 2.25 grams per cubic centimeter (1.3 oz per cu. in.), while the specific gravity of a finer filter sand is 2.70 grams per cubic centimeter (1.56 oz per cu. in.).[3] During the backwash process, when the media bed is stratified (expanded), media granules will classify and layer based on their specific gravity.

In a multi-media filter, larger particulate remains trapped on top of the filter bed as subsequent layers strain increasing smaller particulates as they make their way through the filter bed. In this way, the filter removes more particulates and is less likely to channel or plug.

Backwashing requirements

Backwashing filters need adequate flow and pressure to function properly. Media beds must expand to flush trapped particulates from their filtering surface. Bed expansion ranges from 20 to 50 percent or more. A 30-inch (762-mm) deep media bed will expand to 45 inches during a backwash cycle to achieve 50 percent expansion.

The backwash flow requirements are stated on media manufacturer's operating specifications. Media manufacturers seldom specify a feed water pressure for their required backwash.

Vessels under 12 inches (304.8 mm) in diameter should have 30-psi feed line pressure during backwash. Vessels larger than 12 inches in diameter require 40 psi.

Without adequate pressure, the media will not lift and separate. Remember, by allowing the bed to stratify, the trapped particulates are floated out the top of the vessel through the discharge (backwash) apparatus.

Additionally, bed stratification allows the various media particles to reclassify into their graduated layers. For an example of a manufacturer's operating specification, go to www.clackcorp.com/water/pdf/birm_2350.pdf.

Bed expansion is crucial to proper filter function. If a media bed does not clear itself of particulate loading, particulates will accumulate in the bed and eventually create pressure loss issues.

One issue associated with excess loading is poor-flow or no-flow events through the filter. Another phenomenon common in overloaded filters is channeling. Water, or any non-compressible fluid, will find the path of least resistance to the service outlet when under pressure.

If a portion of the media bed is plugged with particulates, water will channel through a portion of the bed that is less plugged. Channeling is common in media filters that are misapplied and the result is unfiltered water to service.

Expected flow rates

With each of the systems discussed, flow rates can expect to be consistent. This generalization is not intended to be applicable to all systems and/or devices, but meant as a representative indication of what to expect from the systems described.

Screen strainers are relatively coarse filters and offer minimal friction loss to a system. They are susceptible to plugging, but they yield service flow rates similar to the pipe size they service.

A common, one-inch Y-strainer can yield a 16-gpm (60.57 L/m) flow rate at a ΔP of four psi (always check manufacturer's specifications.) It is important to remember that they only filter large particles in comparison to other filtration methods.

Cartridge filters can range from one to 100 µm pore size. It is common to find a maximum flow rate of five gpm through a 9.75 x 2.75-inch (247.65 x 69.85-mm) pleated filter cartridge. It would be inappropriate to install a 10-inch filter housing before a backwashing media filter requiring six gpm or more backwash supply.

Filter selection

There are various designs of whole-house microfilters available to consumers. Some advertise peak flow rates of 11 gpm, but have a continuous flow rate of 4.5 gpm (17.03 L/m).[4] Only continuous flow rate specifications should be used in sizing. A peak flow rate is only a safeguard.

With newer technologies, diligence in reading the operating specifications carefully is essential. Media service flow rates are based on the type of medium in the filter and the design, whether a single medium or multimedia configuration.

Media manufacturers publish operating specifications for the products. These specifications spell out bed depths, temperature limits, backwash requirements and service flow rates.

The most common flow rate for a single medium is five gpm/ft.^{2} (18.92 L/m^2). In doing the math to convert a diameter in inches to square feet of surface area, a 12-inchdiameter vessel provides 0.79 ft.^{2} (0.07 m^2) of filter surface area. At five gpm/ft.^{2} a 12-inch filter has a service flow rate of five x 0.79 = 3.95 gpm (18.92 x 0.07 = 1.32 L/m).

An advantage to a multi-media filter is water clarity at higher flow rates. The same 12-inch diameter vessel, when configured with multiple media layers, provides 5.5 to eight gpm (20.81 to 30.28 L/m).[5]

A filter with multiple layers does strain particles from largest to smallest as they pass through these filter layers. This keeps the particulate from all collecting in the media's top few inches and creating pressure loss and reducing flow. Not only will this configuration provide greater flow, but also due to the vertical depth filtration usage, it can collect more particulates between backwash cycles.

The nuisance-causing microscopic particulates that effect water quality create the same challenges to small systems as they do to larger projects. Therefore, all applications should be treated with the same due diligence; do the homework and ensure that the customer receives that best water possible.

Short cuts should be avoided. Professionals apply sound science, sound engineering and best practices at all times!

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