Tech Brief

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Filter Backwashing

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Photos by **Chris Metzgar**, courtesy of Morgantown Utility Board

Summary

Backwashing a drinking water system filter means reversing and increasing the water's flow to flush out accumulated debris and particles. Backwashing is not only vital to the life of a filter, it is fundamental to the quality of water coming out of the filter. Sooner or later, all filters need to be backwashed or replaced.

What is filter backwashing?

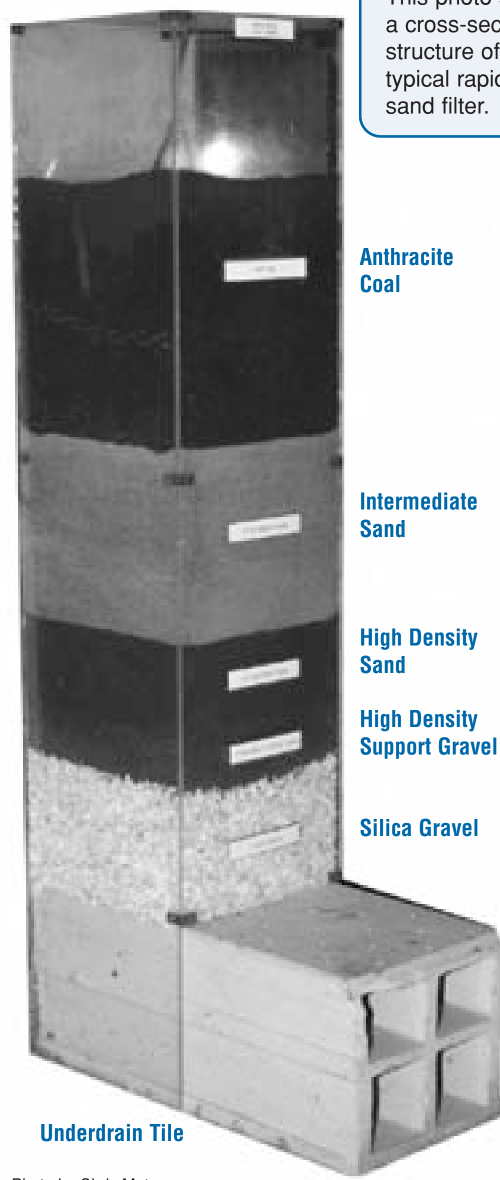
Most drinking water systems use filters to collect, catch, or gather particles from an incoming flow. When the filter's pores become clogged, they need to be cleaned. One of the best ways to clean a drinking water system's filter is to backwash it, meaning reversing the flow and increasing the velocity at which water passes back through the filter. This, in effect, blasts the clogged particles off of the filter. Although every filter is unique, the principles of backwashing are similar for all of them.

One key ingredient to a good filter backwash is using clean water, usually out of the clear well, first storage tank, or distribution system. This *Tech Brief* examines the most common filters: conventional and direct filtration. These filters use either pressure or rapid rate gravity processes.

When to backwash?

The cleanliness or cloudiness (turbidity) of the water coming out of the filter just before it goes into the clear well is the best way to determine when to backwash. A good rule of thumb is 0.1 nephelometric turbidity units (NTU) on each individual filter's effluent. This may sound a little extreme when the combined filter effluent (CFE) for conventional and direct filtration systems is 0.3 NTU. But 0.1 NTU gives the operator time to react to any problems within the treatment system.

Head loss on the filter also indicates the need to backwash. Head loss is usually measured with a negative pressure gauge. As the filter



This photo shows a cross-section structure of a typical rapid sand filter.

Photo by Chris Metzgar

gets clogged, more negative pressure is created. The pressure usually starts near zero pounds per square inch (psi) or approximately one foot of head loss on the clean filter. Then the pressure will increase in a linear fashion in the negative direction to approximately -2.5 to -4 psi on rapid-rate, gravity filters and some pressure filters or about six to 10 feet of head loss. The more clogged the filter, the greater the head loss. This calculation may be different depending on the filter type and make.

Some small plants will just have a clear tube with water indicating pressure differences. The water level in the tube rises as the pressure difference increases. For every one psi measure, there is about 2.31 feet in a column of water. For every one foot in a column of water, there is 0.434 psi of pressure difference. The clear tube can be marked with the pressure difference in negative psi, or it could have a single mark, indicating it is time to backwash.

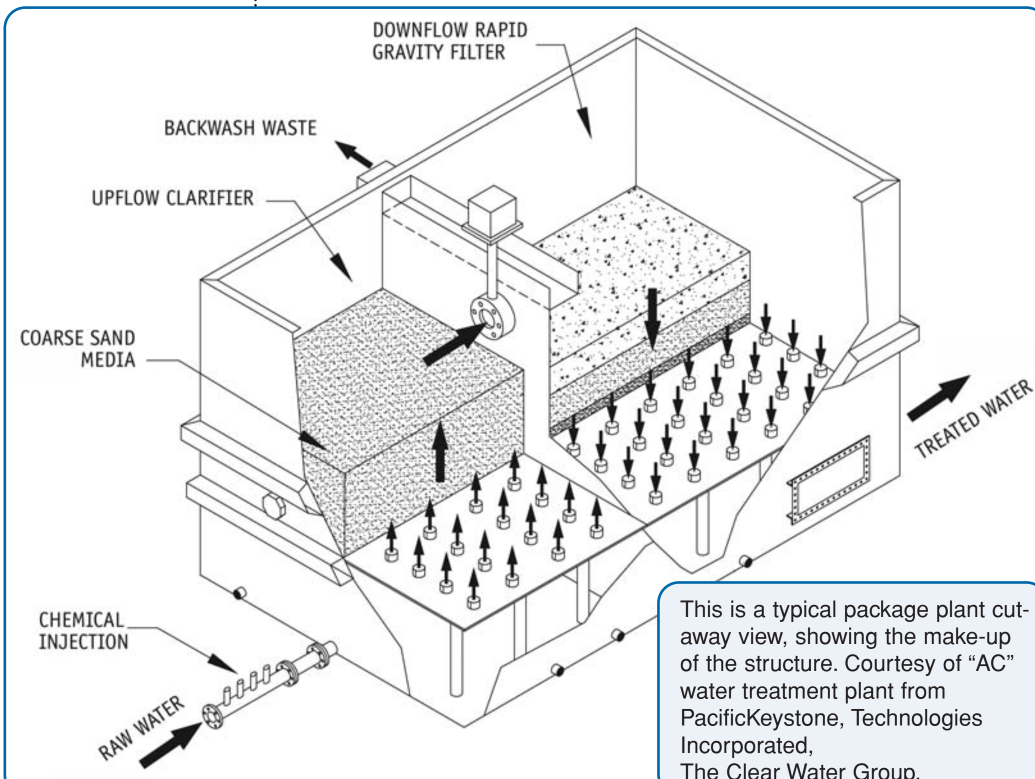
A couple of other indicators really only work when a water system has consistent raw water turbidity. These indicators are gallons filtered or run time. When the raw water is consistent, operators usally can tell when to backwash based on the pump's run time.

How long to backwash?

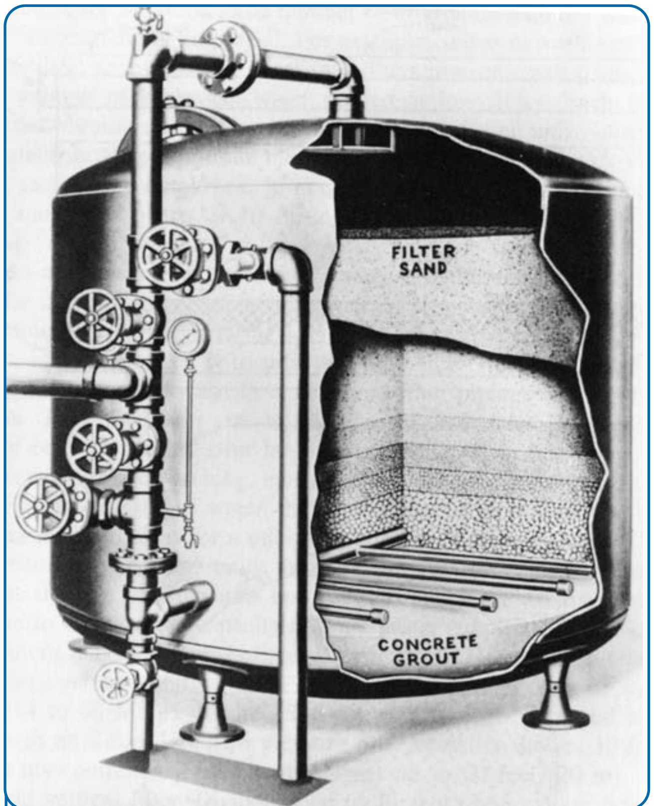
Backwash until the water runs clear (provided there is enough clean water to do unlimited backwashing). Most systems don't have unlimited amounts of clean water, which is why it is important not to get the filter too dirty or overextend the filter run time. Some small systems don't want to use a lot of water while backwashing because they may have limited water set aside in the clear well, or the system could be dealing with drought and must conserve as much water as possible. However, systems should not think of it as wasting water because the filters must be clean to ensure good water quality for their customers.

There are several techniques that can be used to enhance or speed up the backwashing process:

- Add a surface wash system. This system is a series of water jets that can be fixed or a revolving apparatus and comes on at the beginning of the backwash cycle and usually ends before the middle of the cycle. There also can be another series of water jets in the media bed itself (subsurface wash) that come on when the filter bed is fully fluidized (full backwash). For a surface wash to work adequately, at least 45 psi is needed as well as a properly installed vacuum breaker. The flow for fixed nozzles should be two gallons per minute per square foot and 0.5 gallons per minute per square foot for rotating system.
- Add an air scour system. This system is a series of small air pipes with diffusers in the under-drain or above the under-drains that blow uncontaminated air to help break-up mud balls. (The process is similar to when kids



This is a typical package plant cut-away view, showing the make-up of the structure. Courtesy of "AC" water treatment plant from PacificKeystone, Technologies Incorporated, The Clear Water Group.



Typical vertical pressure filter with concrete grout fill in bottom, pipe headers, lateral under drains, gravel support bed, and filter sand, (Courtesy of Infilco Degremont, Inc.) illustration from *Handbook of Public Water Systems,* second edition, HDR Engineering, Inc

blow in the straw in their drinks.) Operators should, however, be careful not to use too much air. Air flow should be between three to five cubic feet per minute per square foot of filter area when the air scour distribution system is in the under-drain; a lower air rate should be used when the air scour distribution system is placed above the under-drains. Sometimes with an air scour system, the backwash rate must be reduced or variable. When air scour is in operation, try not to exceed eight gallons per minute per square foot, unless operating experience indicates that a higher rate is needed to achieve proper backwash. Air scour can be used for the entire backwash period but is typically used only for the first few minutes.

- Use an ordinary, disinfected gravel rake on an open, rapid-rate gravity filter when the filter is in full backwash to help move the backwash process along. Take the rake and move it straight up and down in the fluidized filter media, but be careful not to get into the support-gravel. Raking helps break up the mud balls that form in the media. At first, the rake will be difficult to move, but after several backwashes it will get easier.
- Always spray the side of the filter walls down with clean water using a potable water hose during the backwash on a rapid-rate gravity filter.
- Increase or vary the backwash rate, but not too much since the support gravel could become displaced and creating a big problem.

What should the backwash rate be?

According to most design manuals, the minimum backwash rate on a rapid-rate gravity filter should be eight to 15 gallons per minute per square foot of filter area, depending upon whether the filter is equipped with an air scour system (eight gallons per minute per square foot if it is equipped with an air scour system and 15 gallons per minute per square foot of filter area if it is not equipped with an air scour system). The backwash rate should be adjustable if not variable. While it may never be used, it is good practice to design for a maximum of 20 gallons per minute per square foot of filter area. For rapid-rate pressure filters, the backwash rate should be at least 15 gallons per minute per square foot of filter area.

How much expansion should the filter bed have?

During the backwash cycle, the filter media bed expands. Pumping water back through the system from the bottom up causes this expansion. A filter bed should have as much expansion as possible without losing media or displacing the support gravel. Most engineering manuals state that filter bed expansion should be 30 to 50 percent. Realistically, a 15 to 20 percent expansion area will get the filters clean with the proper backwash duration. Thirty inches of filter media (sand and anthracite) should expand the bed from 4.5 to six inches when in full backwash. The backwash rate regulates the expansion. If the backwash rate is too high, expansion will be too much and could possibly displace the support gravel below the filter media, or it could blow the filter media onto the ceiling of the filter room.

Backwash Water

Backwash water is very dirty, and there is no sense in taxing the water system if it's not necessary. The best and easiest way to eliminate backwash water is to have a backwash line with proper backflow prevention connected to the nearest sanitary sewer. When discharging the backwash water into the sanitary sewer, make sure not to overload the system. Overloading could cause back-ups in the sewer system, as well as into peoples' homes. Backwashing also can create havoc for the sewer plant at peak flows. If it is not possible to discharge into a sanitary sewer, then a basin or basins can be used to settle out the solids, while the top portion is skimmed (decanted) and then emptied into a nearby stream or river with the proper National Pollutant Discharge Elimination System (NPDES) permits. Backwash water also can be pumped and then transported to a sewer plant or landfill.

Backwash recycling capability is another option that can come in handy in times of need, such as a drought. If it is standard procedure or if state laws require systems to recycle backwash water, a separate basin or basins capable of holding several backwashes can be used to settle out solids and decant the water back to the head of the plant. Remember, the Filter Backwash Recycling Rule includes a provision that no more than 10 percent of the incoming flow can be decanted backwash water.

After Backwash

Several techniques can be employed to avoid the dreaded turbidity spike, which is the first slug of water that comes through the filter after the backwash cycle once the filter is operational again. This turbidity spike can occur anywhere from a few minutes to 40 or more minutes after returning to filter operation mode. The turbidity can vary from a negligible NTU to as high as 1.5 NTU or more. If the turbidity on the individual filter gets any higher, there may be problems with the filter or the filter backwash.

One easy way to avoid the turbidity spike is to let the filter "ripen." Ripening the filter means that the operator allows the filter to sit for a while after the backwash cycle. Some small plants can even perform the backwash at the end of the day, before the filter is shut down and allow the filter to sit overnight. Filter ripening takes from 30 minutes to 24 hours. In most cases, however, the longer the filter sits, the better. Filter ripening doesn't cost anything and requires no special piping, but many systems don't have the luxury of this time.

How long should filter-to-waste be?

One of the most common techniques of eliminating the turbidity spike is filter-to-waste, meaning that the first slug of filter water after backwash is directed to the sanitary sewer or the backwash basin. Filtering-to-waste should continue until the turbidity spike subsides—the less turbidity in the clear well the better. If the system doesn't have filter-to-waste capability, it would be a good investment to install the appropriate piping. The best way to monitor the turbidity is with a continuous in-line turbidity meter on each individual filter. If there is no in-line turbidity meter, a tap connected to the individual filter effluent line can be used in conjunction with a bench-top turbidity meter and a stop watch to take water samples at one-minute intervals for the first five minutes and then two-minute intervals for at least 20 minutes or until the turbidity goes below 0.1 +/- NTU after the backwash cycle. Be sure to use clean sample containers, such as white star foam cups already labeled with the time interval on each cup.

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