# 10 Filtration

A trickle or drip system uses an emitter to regulate flow rates. The emitter utilizes small flow paths and orifices to achieve a low flow rate. These small paths and orifices are easily susceptible to plugging by material and chemicals in the irrigation water supply. Adequate filtration is the key component to a successful drip / trickle irrigation system. This chapter provides information on filtration requirements for trickle irrigation systems.

## 10.1 Causes of Emitter Clogging

An emitter can become totally plugged or have its flow rate reduced by:

- organic material carried by the water supply
- growth of algae and other bacterial slimes within the lateral lines and emitters
- silts, clays and other inorganic particles in the water supply
- precipitation of chemicals inside the trickle system

### Organic Material

Organic material can be present in the irrigation water supply at the source or grow in the supply lines or trickle system during the irrigation season. The amount of organic material present will depend on the water source. Open and stagnant water sources such as ponds can contain a large amount of organic debris. Large organic debris can be filtered out but many types of algae are small enough to pass through the filtration system as individual particles. These particles can then flocculate in the lines and clog the emitter passages by forming a bridge across the emitter orifice. Figure 10.1 shows examples of this bridging effect.

### Bacterial Growths

Iron and sulfur bacterial growths may also occur. Iron precipitating bacteria grow in the presence of dissolved ferrous iron. The bacteria attach to surfaces inside the laterals and emitters and oxidize the dissolved iron, causing ferric iron to precipitate. The bacteria cause a slime called ochre to develop which can quickly clog an emitter.

Sulfur slime is produced by certain bacteria that can oxidize hydrogen sulfide producing an insoluble elemental sulfur. A white or yellow stringy deposit can develop. Slimes are often sticky, acting as an adhesive surface for smaller particles to adhere to.

Chapter 11 provides information on how to treat systems that have algae growth or bacterial slime problems.

## Particulate Matter

Inorganic particles such as sand, limestone or other debris that is too large to pass through the emitter will cause clogging. Even fine clays that are suspended in the water can clog an emitter by flocculating together to form larger particles. Figure 10.1 graphically shows this bridging effect.

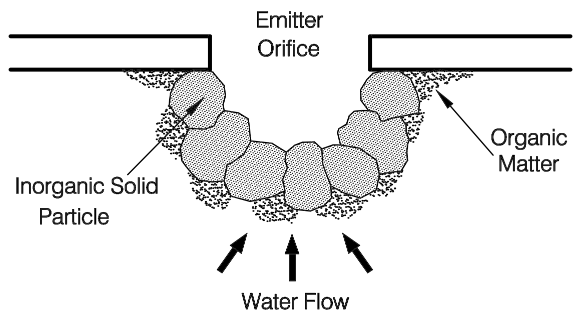



*Figure 10.1* *Particle Bridging in an Emitter*

## Chemical Precipitates

Chemical clogging usually results from calcium, iron, magnesium or manganese of sufficient quantity being present in the water supply. These minerals can precipitate from solution and form scale that partially or completely clogs an emitter. Precipitation can be caused by changes in pH, temperature, pressure, exposure to oxygen in the air, other ions in solution or even fertilizers that are injected through the system.

Chapter 11 provides information on the treatment of chemical precipitates and the maintenance of trickle systems. Chapter 12 discusses options for the injection of fertilizers and fertilizer selection to prevent chemicals from precipitating.

# 10.2 Selecting a Filtration System



Every trickle irrigation system should have some type of filter to protect the system from excessive plugging. Emitter plugging should not go unchecked as the uneven water distribution will lead to poor system performance and may eventually cause plant stress or damage. Selecting the right type of filter can save time and money. Before selecting a filter determine the following:

- Understand what is in the irrigation water. Testing the water will provide the information needed to properly assess filtration and maintenance requirements. The size, nature and concentration of the contaminant in the water supply will determine the type of filter that is required.
- Determine the emitter orifice size. The size of the openings in the emitter will determine the degree of filtration required.
- Determine the peak flow rate of the irrigation system. The filter must be sized to work at the peak flow rate that is expected.
- Cost of various options. Sometimes there is a choice as to the type of filter that can be used. The cost of automation and maintenance must be added to the capital cost to determine which filter would be the best option.

The size of the emitter orifice determines the degree filtration that is required. Suspended solids are capable of plugging an emitter orifice by forming a bridge network of up to seven or eight particles. Figure 10.2 shows the various mesh sizes versus the size of a 0.020 inch diameter emitter orifice.

To prevent the buildup of this bridge network, for microjet and other spray emitters a filtration unit must be able to remove all particles that are larger than one- seventh of the emitter orifice diameter. Emitters that have a long flow path must have even better filtration, up to 10 times the emitter orifice diameter. Where fine organic material is present, particles larger than one-tenth of the emitter orifice diameter may have to be removed. Table 10.1 can be used to compare between inches, mm, micron and mesh units.

**Table 10.1 Unit Comparison for Emitter Orifice Size**

| Inches | mm | Micron | Mesh Equivalent |
|---|---|---|---|
| 0.0280 | 0.7110 | 711 | 20 |
| 0.0165 | 0.4200 | 420 | 40 |
| 0.0071 | 0.1800 | 180 | 80 |
| 0.0060 | 0.1520 | 152 | 100 |
| 0.0049 | 0.1250 | 125 | 120 |
| 0.0041 | 0.1050 | 105 | 150 |
| 0.0035 | 0.0890 | 89 | 180 |
| 0.0030 | 0.0740 | 74 | 200 |
| 0.0021 | 0.0530 | 53 | 270 |
| 0.0017 | 0.0440 | 44 | 325 |

0.001 inches = 25 microns

The mesh equivalent is used to determine the degree of filtration required for various emitters. Screen and disc filters are rated by mesh size and sand filters use a sand designation number that refers to a screen mesh equivalent. See Sections 10.5, 10.6 and 10.7. Equations 10.1 and 10.2 can be used to determine the Mean Filter Capability (MFC) required for various emitter orifice diameters. The emitter orifice diameter may be given in any units. Use Table 10.1 to convert the units to a screen mesh equivalent.

For drip emitters:

**Equation 10.1**

$$MFC_d = \frac{\text{Emitter Orifice Diameter}}{10}$$

For spray emitters:

**Equation 10.2**

$$MFC_s = \frac{\text{Emitter Orifice Diameter}}{7}$$

**Example 10.1 Determining Filtration Requirements**

Determine the degree filtration required for a along flow path emitter that has an orifice diameter of 1100 microns.

Using Equation 10.1 the $MFC_d = \frac{1100}{10} = 110$ microns

Interpolating from Table 10.1 the screen mesh equivalent is 140 mesh.

Table 10.2 provides a guide to filter type selection based on water quality. It should be noted that this is only a guide and that other factors may warrant a different filter selection. The levels of organic and inorganic loading are based on water quality tests that were conducted on Okanagan water supplies.

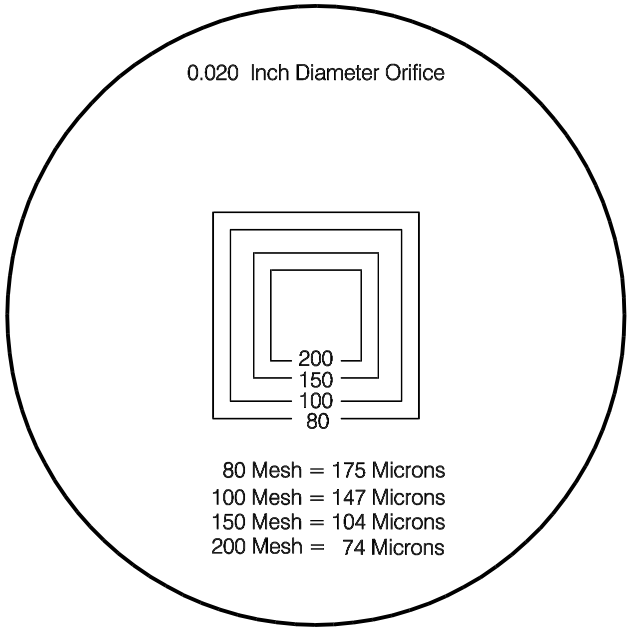



*Figure 10.2 Comparison of Screen Mesh Sizes with a 0.20" Emitter Orifice*

Table 10.3 provides specific information on the degree of filtration required for various emitter types, use Equations 10.1 and 10.2 as a guide and obtain the screen mesh equivalent from Table 10.1. Additional information on the sand media designation provided in the table is given in Section 10.7.

The information provided in Tables 10.3 takes into consideration the length of the emitter flow path and manufacturer's recommendations if they have been given. The filtration requirements shown should be considered the minimum that is required for the emitter type listed. Not all products sold in British Columbia may be listed. Check with the manufacturer if there is any doubt.

To protect emitters from dirt entering the laterals due to breakages, a minimum 80 mesh screen should be installed on all trickle irrigation systems using emitters with orifice sizes larger than 0.06 inches (1500 microns).

**Table 10.2 Filter Selection**

| Type of Material and Concentration | | Filter Selection |
|---|---|---|
| **Organic** | **Inorganic** | |
| < 5 mg/L | < 5 mg/L | Manual Screen Filter |
| | 5 - 10 mg/L | Manual Disk Filter |
| | > 10 mg/L | Automatic Screen or Disk |
| 5 - 10 mg/L | < 5 mg/L | Automatic Screen or Disk |
| | 5 - 10 mg/L | Manual Sand Media |
| | > 10 mg/L | Manual Sand Media |
| > 10 mg/L | | Automatic Sand Media |

**Table 10.3 Minimum Filtration Requirements for Various Emitter Types**

| Emitter Type | | Passage Diameter | | Minimum Filtration | |
|---|---|---|---|---|---|
| | | Inches | Microns | Screen Mesh | Sand Media |
| Vortex | | | | 150 | #11 Crushed Granite |
| E2 | | .030 | 760 | 200 | #20 Silica Sand |
| Turbo Key | | .035 | 900 | 120 | #12 Silica Sand |
| T-Tape | | | | 200 | #20 Silica Sand |
| Chapin Drip Tape | | | | 150 | #11 Crushed Granite |
| Roberts Ro-Drip | | | | 200 | #16 Silica Sand |
| All long flow Path Emitters | | | | 200 | #20 Silica Sand |
| Microtube | | .020 | 500 | 250 | #20 Silica Sand |
| | | .025 | 635 | 200 | #20 Silica Sand |
| | | .035 | 890 | 180 | #16 Silica Sand |
| | | .045 | 1140 | 150 | #11 Crushed Granite |
| | | .060 | 1525 | 100 | #8 Crushed Granite |
| Microjet | | .020 | 500 | 200 | #16 Silica Sand |
| | | .030 | 760 | 150 | #11 Crushed Granite |
| | | .040 | 1120 | 100 | #8 Crushed Granite |
| | | .050 | 1270 | 80 | #8 Crushed Granite |
| | | .060 | 1525 | 80 | #8 Crushed Granite |
| | | .070 | 1780 | 80 | #8 Crushed Granite |
| <u>Rain Bird</u> | | | | | |
| Rain Tape TPC | | | | 200 | #20 Silica Sand |
| Dripline PC | 0.42 gph | | | 120 | #11 Crushed Granite |
| Dripline PC | 0.61 gph | | | 120 | #11 Crushed Granite |
| Dripline PC | 0.92 gph | | | 120 | #11 Crushed Granite |
| TPC Emitters | 0.5 gph | | | 200 | #16 Silica Sand |
| TPC Emitters | 1.0 gph | | | 200 | #16 Silica Sand |
| TPC Emitters | 2.0 gph | | | 200 | #16 Silica Sand |
| Lady Bug Emitters | 0.5 gph | | | 200 | #16 Silica Sand |
| Lady Bug Emitters | 1.0 gph | | | 100 | #8 Crushed Granite |
| Lady Bug Emitters | 2.0 gph | | | 100 | #8 Crushed Granite |
| Micro-Quick - blue .040 | | | | 150 | #11 Crushed Granite |
| Micro-Quick - violet .045 | | | | 150 | #11 Crushed Granite |
| Micro-Quick - green .050 | | | | 120 | #11 Crushed Granite |
| Micro-Quick - red .060 | | | | 120 | #11 Crushed Granite |
| Micro-Quick - white .070 | | | | 100 | #8 Crushed Granite |
| <u>Netafim</u> | | | | | |
| Python | 0.23 gph | .024 | 600 | 200 | #20 Silica Sand |
| Python | 0.40 gph | .028 | 700 | 200 | #20 Silica Sand |
| Triton | 0.50 gph | .055 | 1375 | 120 | #12 Silica Sand |
| Triton | 1.0 gph | .053 | 1325 | 120 | #12 Silica Sand |
| Triton | 2.0 gph | .075 | 1875 | 80 | #8 Crushed Granite |
| Streamline | 0.23 gph | .018 | 450 | 320 | #20 Silica Sand |
| Streamline | 0.40 gph | .021 | 525 | 270 | #20 Silica Sand |
| Ram | 0.42 gph | .044 | 1100 | 140 | #11 Crushed Granite |
| Ram | 0.61 gph | .048 | 1200 | 120 | #12 Silica Sand |
| Ram | 0.92 gph | .052 | 1300 | 120 | #12 Silica Sand |
| Typhoon | 0.40 gph | .028 | 700 | 200 | #20 Silica Sand |
| Typhoon | 0.60 gph | .032 | 800 | 180 | #16 Silica Sand |
| PC Drippers | 0.50 gph | .057 | 1425 | 120 | #12 Silica Sand |
| PC Drippers | 1.0 gph | .065 | 1624 | 100 | #8 Crushed Granite |
| PC Drippers | 2.0 gph | .065 | 1625 | 100 | #8 Crushed Granite |
| WPC jr | 0.5 gph | .041 | 1025 | 150 | #11 Crushed Granite |
| WPC jr | 1.0 gph | .051 | 1275 | 120 | #12 Silica Sand |

# 10.3 Storage Reservoirs



Storage reservoirs or ponds can provide some filtration for water that is heavily laden with silt or where an iron oxide problem persists, see Section 11.4. If the water source has suspended solids exceeding 200 mg/L a pond or settling basin can be useful in reducing the amount of material that must be filtered by the trickle irrigation system filters. Reservoirs that are being designed as settling basins should incorporate the following:

- The intake to the trickle irrigation system should be as far as possible from the water entering the reservoir.
- The reservoir must be able to be drained for silt removal at the end of the season.
- The irrigation intake should draw the water from as close to the reservoir surface as possible.
- The reservoir shape should be long and narrow rather than square to allow for effective sediment removal. Table 10.4 provides information on the settling velocities for different particle sizes.
- Filtration backflush water should be returned to the reservoir as far as possible from the irrigation intake.

*Figure 10.3* *Storage Reservoir*

| Table 10.4 | Settling Velocities for Various Particle Sizes | | | | |
|---|---|---|---|---|---|
| Soil Texture | Particle Size | | | Settling Velocity | |
| | In | mm | Microns | Ft/min | m/min |
| Coarse Sand | 0.02-0.04 | 0.50-1.0 | 500-1000 | > 126 | > 38 |
| Medium Sand | 0.01-0.02 | 0.25-0.50 | 250-500 | 71 | 22 |
| Fine Sand | 0.004-0.01 | 0.10-0.25 | 100-250 | 16 | 5 |
| Very Fine Sand | 0.002-0.004 | 0.05-0.10 | 50-100 | 2.8 | 0.9 |
| Silt | 0.00008-0.002 | 0.0002-0.05 | 2-50 | 0.05 | 0.015 |
| Clay | < 0.00008 | < 0.0002 | < 2 | < 0.0002 | 0.0006 |

How quickly suspended solids settle out depends on the size and specific gravity. Due to the long settling time of clay particles, it is impractical to settle them out in a reservoir. The particles are also so small that filtration systems will most likely not be able to remove them. These particles must therefore be kept in suspension so they move through the trickle system and exit through the emitters. If plugging is to occur it will most likely happen near the ends of the laterals where flow velocity are very low. Additional line flushing may be required to ensure the ends of the laterals are kept clean.

The settling time can be calculated from Table 10.4 as follows:

$$\text{Settling Time} = \frac{\text{Distance from Pond Surface}}{\text{Settling Velocity}}$$

**Example 10.2 Silt Settling Calculation**

A water source contains enough silt to quickly load the trickle irrigation filtration system. The silt is to be removed by a settling pond. The pump intake for the trickle irrigation system is 1 meter below the surface of the pond. Calculate the minimum settling time required.

From Table 10.4 - the settling time is 0.015 m /min

$$\text{Settling Time} = \frac{1\text{ m}}{0.015\text{ m /min}} = 67\text{ minutes}$$

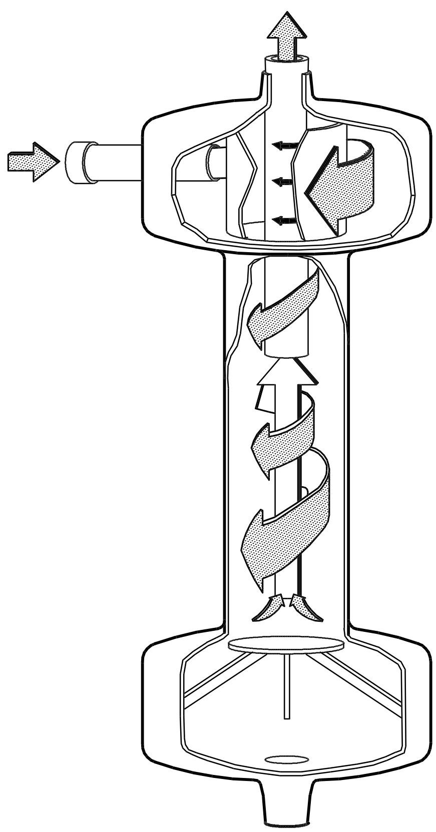
While reservoirs can be useful to settle suspended solids, they can also increase the amount of organic material in the water through the growth of algae and bacteria. The water should be analyzed to determine what type of filtration system should be installed on the trickle irrigation system.

# 10.4 Sand Separators

Sand separators swirl the water in a chamber creating a centrifugal force that causes sand and other heavy particles to settle out of the water supply. These units are very effective as they use no moving parts and have no screen that requires cleaning. See Figure 10.4. The collection chamber on the bottom of the unit must be drained frequently to prevent the solids that accumulate from blocking the unit. *Separators are not effective in removing organic material or other particles that are not heavier than water.*

To function properly separators must be operated at the correct flow rate. This presents a problem for irrigation systems that have zones with flow rates that vary significantly. The operating range for centrifugal separators corresponds to a pressure drop of 5 to 11 psi. If the pressure drop is less than 5 psi the flow rate will be too low to create a sufficient centrifugal force to settle out the particles. Unlike screen and media filters where the pressure drop increases as they become dirty, the pressure drop across a separator will remain constant as long as the flow is constant.

Separators are effective in removing up to 95% of dense particles that are greater than 200 mesh in size. Since separators cannot remove all of the material, they can only be considered as a pre treatment prior to the trickle irrigation filtration system.



*From: Claude Laval Corp.*

*Figure 10.4* *Centrifugal Sand Separator*

## 10.5 Screen Filters

Screen filters are effective primarily for removing inorganic particles from the water supply. As water passes through the screen filter, the screen mesh blocks particles that are larger than the mesh from passing through. As the mesh becomes blocked or plugged the pressure differential across the screen increases. The screen could eventually burst if the pressure becomes too great. The mesh fabric may also expand allowing the particles to be extruded through mesh at higher pressure differentials. Proper maintenance is required to ensure that the pressure differential is kept at an adequate level.

Screen systems can be effective and economical under the right conditions and if the correct system is selected for the job. Table 10.5 provides the screen openings for various mesh screens. This information is similar to that shown in Table 10.1 but has been reorganized to show screen openings.

**Table 10.5 Stainless Steel Mesh Data**

| Meshes per Inch | Wire Diameter Inches | Opening Width Inches | Percent Open Area |
|---|---|---|---|
| 80 | 0.0055 | 0.0070 | 31.4% |
| 100 | 0.0045 | 0.0055 | 30.3% |
| 120 | 0.0037 | 0.0046 | 30.7% |
| 140 | 0.0029 | 0.0042 | 34.9% |
| 150 | 0.0026 | 0.0041 | 37.4% |
| 180 | 0.0023 | 0.0033 | 34.7% |
| 200 | 0.0021 | 0.0029 | 33.6% |
| 220 | 0.0017 | 0.0028 | 38.7% |
| 240 | 0.0016 | 0.0026 | 38.3% |
| 250 | 0.0016 | 0.0024 | 36.0% |
| 325 | 0.0014 | 0.0017 | 30.7% |

### Manual Flush Systems

Water that contains a significant amount of organic contaminants cannot be successfully filtered with a manual flush screen filter. Screen filters do not have the capacity to remove and hold large amounts of organic particulate without severely curtailing the flow through the filter. Automatic flush filters can be more effective but will still be limited if there is a large amount of organic material in the water supply.

There are numerous types of screen filters on the market which are available for a variety of applications. The thru-flush model is a common type of screen filter. During the filtration mode particles are filtered out of the water on the inside of the screen mesh.

This type of screen can be quickly cleaned by opening the flush valve and allowing a gush of water to wash the accumulated contaminants out the flush port. A polymeric or stainless steel mesh, available in 30 to 200 mesh, is often used for trickle irrigation systems. The filter should be installed with the outlet pointing down so that debris from the screen will not drop into the outlet port when the screen removed for cleaning.

Figure 10.5 shows the operation of a screen filter. Figure 10.6 shows how a number of screen filters can be combined to increase the filtration capacity.

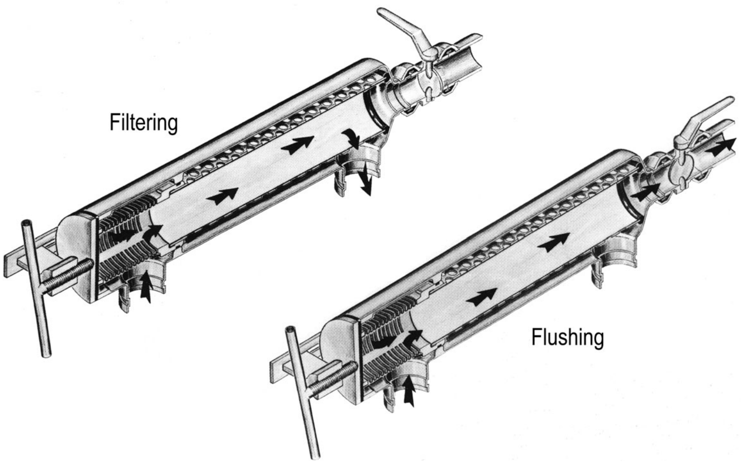



*Figure 10.5* *Thru Flush Screen Filter*

*Figure 10.6* *Manifold of Screen Filters*

## Automatic Flush Systems

A thruflush screen filter, as with some other filters, can be automated by using a pressure sensitive flush valve. This is done by monitoring the pressure before and after the screen. When the pressure difference reaches a preset amount the valve is activated and flushes the screen.

Another method is to use a solenoid valve on the outlet to the flush the screen at preset time intervals. Figure 10.7 shows a solenoid valve installed on a thru flush screen filter. Other types of automatic screen filters are also available as shown in Figure 10.8.

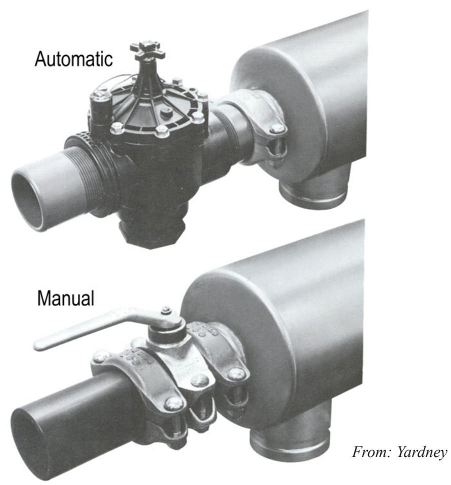



*Figure 10.7 Automation of Thru-Flush Screen Filter*

*Figure 10.8 Automated Self Cleaning Screen*

## Sizing a Screen Mesh Filter

A recommended flow velocity through a screen mesh filter is 0.5 ft/sec. Manufacturer's standards for rating maximum flows may vary. When selecting a screen filter, check the specifications to determine the flow velocity. All mesh filters are designed and rated to provide a maximum gpm flow rate with average water source conditions. If heavy slug loadings occur or if poor water conditions exist, additional screen surface area will be required for the filter to operate satisfactorily.

The capacity of a mesh filter at a 0.5 ft/sec flow velocity through the mesh can be calculated by using Equation 10.3.

**Equation 10.3** **Screen Open Area ($ft^2$) x 225 = filter capacity in gpm**

The surface area required for a screen filter can be determined from Equation 10.4.



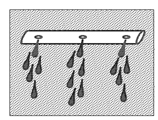
**Equation 10.4**

$$SA = \frac{Q\ (gpm)}{448 \times V(ft/sec) \times \%O_p}$$

where:

| | | |
|---|---|---|
| SA | = | Screen surface area ($ft^2$) |
| Q | = | System flow velocity in gpm |
| V | = | Flow velocity through the screen (ft/sec) |
| $\%O_p$ | = | Open Area of the Screen Mesh (% shown as a decimal) |

**Example 10.3 Screen Filter Sizing**



The linear tape system used in Example 7.1 has a flow rate of 28 gpm per zone. The emitter used has an orifice opening of 0.03 inches. The water supply from the well has no organic content with inorganic suspended solids of less than 5 mg/L. A screen filter will therefore be used. Determine the mesh and screen surface area required using the recommended flow velocity of 0.5 ft/sec.

Using Equation 10.1

$$MFC_d = \frac{0.03}{10} = 0.003$$

Determine Mesh Size:
From Table 10.1
The screen mesh equivalent required for a mean filter capability of 0.003 is 200 mesh.

Determine Screen Surface Area:
From Table 10.5
The percent open area of a 200 mesh screen is 33.6%.

Using Equation 10.4

$$SA = \frac{28}{448 \times 0.5\ ft/sec \times 0.336} = 0.37\ ft^2$$

A 200 mesh screen with a surface area of 0.37 $ft^2$ is required.

## 10.6 Disk Filters

Disk filters consist of a series of grooved rings which, when tightened together, form a cylindrical filter. Different degrees of filtering can be achieved by changing the size of the grooves. Like screen filters, disk filters are rated by a mesh equivalent. The mesh rating is often shown by the colour of the rings. Disk filters are available with mesh ratings from 40 to 400 mesh. Since the filtration area is three dimensional, disk filter manufacturer's may also provide a filtering volume in addition to the filter surface area.

Backflushing can be done manually or automatically. Figure 10.9 illustrates the manual cleaning of a disk filter. During filtration the rings are compressed together. In the backflush mode the rings are separated and the particles are removed with the backflush water. Disk filters generally require less backflush water than screen filters and can backflush quickly.

Since disk filters have a higher loading capacity than screen filters less cleaning will be required. To effectively backflush disk filters automatically, the rings must separate easily. Organic material and chemical precipitates may cause the rings to stick together preventing adequate backflushing.

The flow rate through a disk filter can vary from 5 gpm to 80 gpm / $ft^2$ surface area, depending on the water quality, the mesh equivalent of the disks, organic loading in the water and the allowable pressure difference across the disks. Filters are available in a flow rate range from 5 to 3000 gpm. To reduce the frequency of backflushing, a recommended flow rate is 10 gpm / $ft^2$ of surface area. The surface area required can be obtained by stacking disk filters into a manifold. See Figure 10.10. Manifolds can have 15 or more disk filters operating in tandem. Figure 10.11 shows the operation of a disk filter.

*Figure 10.9* *Manual Cleaning of a Disk Filter*

*Figure 10.10* *Disk Filters in Tandem*


*Figure 10.11* *Disk Filter Operation*

## 10.7 Sand Media Filters

Sand media filters are most effective for the removal of suspended inorganic and organic particulates from the water supply. These types of filters are capable of extracting and retaining large volumes of suspended solids while continuing to deliver the rated flow of filtered water. Sand media filters should be considered whenever the water supply has an organic matter content that exceeds 10 mg/L.

Sand media filters are usually shaped as a cylindrical tank. The diameter of the tanks range from 2 to 4 feet (0.6 - 1.2 m). The inside of the tank contains a sand bed ranging in thickness from 10 to 20 inches (25 to 50 cm). The sand media filter can store more material than screen or disk filters as the particles are trapped in several inches of sand media rather than just the surface of the filter.

Sand media filters are always installed in multiple units so that clean water from one unit or units can be used to backflush the other. To increase the filtration capacity additional units are added. Figure 10.12 shows the configuration of different sand media filtration systems.

*Figure 10.12* *Sand Media Filters*

## Filtration Mode

During the filtration mode, the supply water enters the filter at the top, passes through the sand bed and exits at the bottom of the filter bed (See Figures 10.13 and 10.15). The clean water leaving the sand filter is still under pressure, and combines with the clean water from one or more additional filters before being channeled into the irrigation system. The filter is designed so that water passes uniformly throughout the filter bed, preventing water channelling through the sand media. The sand media is supported in the tank by an underdrain.

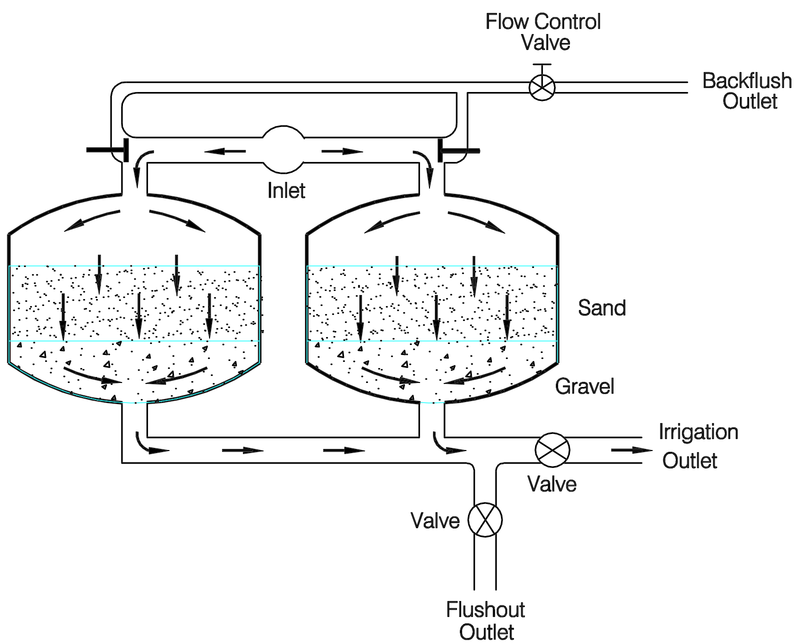



*Figure 10.13* *Sand Media Filter – Filtration Mode*

## Backflush Mode

Sand media filters are cleaned by reversing the water flow through the bed. This process expands the sand media allowing trapped debris to be carried out the backwash water. (See Figures 10.14 and 10.15). The backflush flow rate must be sufficient to expand the sand media to purge out all particulates while ensuring that the media itself is not expelled from the tank. A flow control valve on the backflush line is beneficial for ensuring that the proper backflush flow rate is used. Clean water should always be used in the backflush process. Sand media filters must therefore always use at least two filters so that clean water from one of the filters can be used to backflush the other filter.

The dirty backflush water should be discharged to an appropriate drain. During the backflush process some particulates and fine sand may be circulated to the bottom of the sand filter. To prevent this material from migrating into the irrigation system upon start-up of the filtration mode, a backup screen filter should be installed after the sand media filter.

A sand media filter should be backflushed whenever the pressure differential across the sand bed exceeds 5 psi above the clean operating pressure differential of the sand bed. The total pressure difference should not exceed 10 psi.

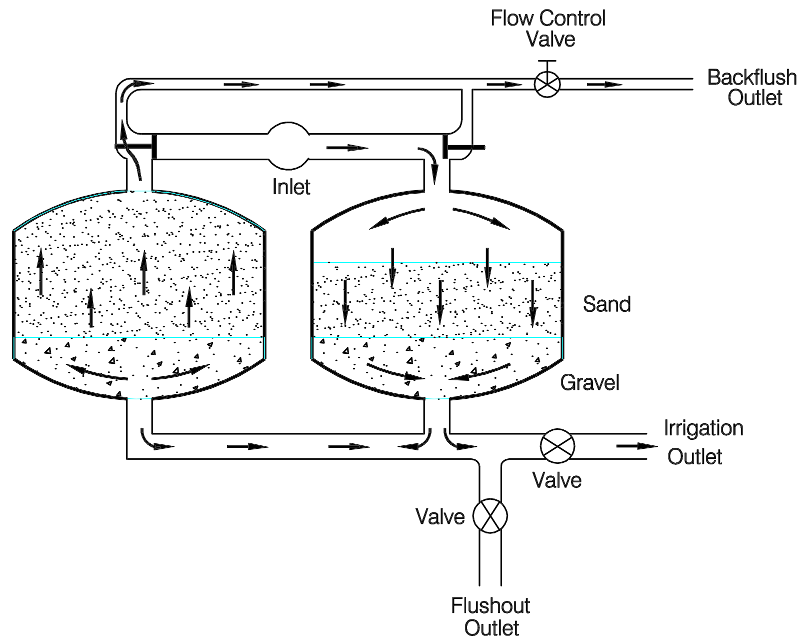



*Figure 10.14* *Sand Media Filter – Backflush Mode*

## Underdrains

The purpose of the underdrain is to:

- Allow clean water to exit the filter tank but keep the sand in the tank.
- Distribute the backflush water evenly throughout the media bed to obtain an effective backwash.

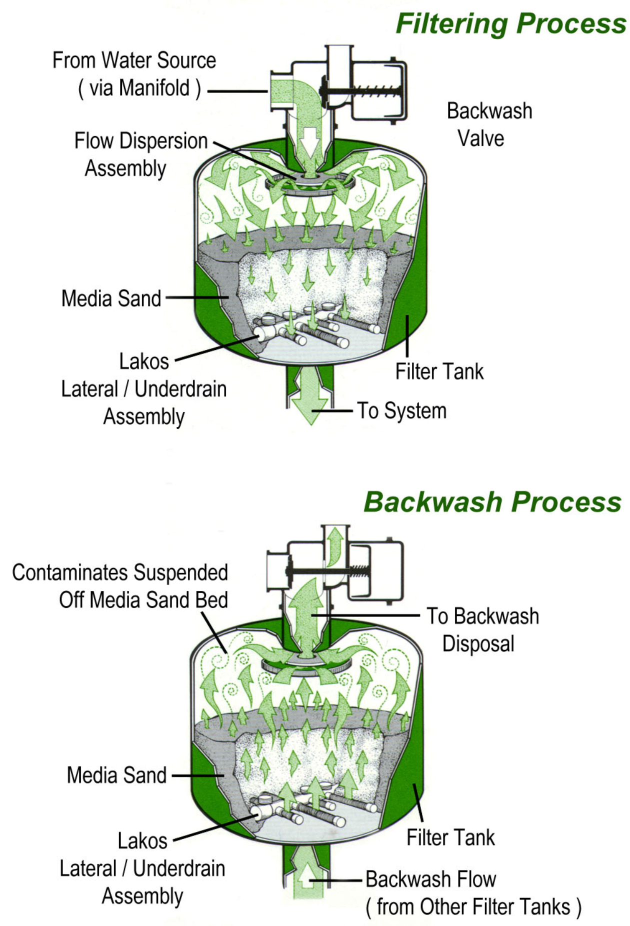
Two types of underdrain designs that are commonly used are an epoxy composite cake and the lateral or slotted underdrain.

The epoxy composite underdrain is made from fine crushed granite that is laid on top of an epoxy bonded gravel. The resulting cake has a very large open surface area resulting in an even distribution of water in both the filtration and backflush mode. The pressure drop across the underdrain is also very low due to the large open area. The opening size in the cake should be matched to the type of sand to be used. Fine sand will require a finer epoxy cake.

The disadvantages of an epoxy underdrain is that if the cake becomes plugged with algae or small clay particles it must be removed and replaced. Acid or chlorine baths may partially restore some cakes that are not severely plugged. Table 10.6 provides information on shock chlorine and acid treatments. The cake can crack during the backflush mode when plugged as the pressure differential across the bed may be excessive. Cakes also degrade over time.

Lateral or slotted underdrains are popular because of their durability and ease of service. A gravel pack is generally required to support the media bed, keep it separated from the underdrain slots and to help disperse the backflush water evenly across the bottom of the media bed. The gravel bed should be made up of ½” crushed gravel to a depth of 3” over the highest point of the underdrain.

Excessive backflushing may cause the sand media to get mixed with the gravel thereby losing its effectiveness. The underdrain slots should always be sized to the sand media to prevent the slots from becoming plugged.




*From: Claude Laval Corp.*

*Figure 10.15* *Slotted Pipe Underdrain Assembly*

## Underdrain Maintenance

It may be possible to treat plugged underdrains of sand filters with either chlorine, for organic plugging or an acid if plugged with inorganics. The following steps should be followed.

1. Ensure that rinse water is available for safety to rinse of chemicals which may come in contact with the operator.
2. Remove the inspection ports and fill each tank with water to the top of the weld seam. It is not necessary to remove the sand. Make sure the valve outlet to the field is closed so the water will stay in the tank.
3. Do not mix chemicals in this procedure and always add the chemicals to a water filled tank. ***Do not do chlorine and acid treatments at the same time. Chlorine and acid should never be mixed.***

4. For chlorine treatment:
   - Add 12% pool chlorine as indicated in Table 10.6. If using 6% household chlorine, then double the amount.
   - Allow to stand for 24 hours.
5. For acid treatment:
   - Add 31.4% pool acid in the amount indicated in Table 10.6
   - Allow to stand for 5 hours.
6. Replace the inspection port but do not bolt down tightly during the treatment.
7. Place a sign near the tanks indicating that chemical treatment is in process.
8. After the treatment period is complete, bolt down the inspection ports, open the shutoff valve to the field and initiate a backflush cycle. Flush each tank for 3 minutes and repeat this process several times. Then 1initiate an irrigation cycle to complete the flushing process.

One or two treatments should usually be enough to unplug the underdrain. If not consult the manufacturer.

**Table 10.6 Sand Filter Shock Treatment**

| Tank Diameter inches | Liquid Pool Chlorine litres | Liquid Pool Acid litres |
|---|---|---|
| 14 | 0.475 | 0.25 |
| 18 | 0.775 | 0.40 |
| 24 | 1.25 | 0.62 |
| 30 | 2.2 | 1.1 |
| 36 | 3.25 | 1.6 |
| 44 | 5.5 | 2.75 |
| 48 | 7.6 | 3.8 |

## Installation and Setup

Effective performance of a sand media filter is only possible if installed and setup correctly before beginning operation. A good check is to determine what the pressure loss across the sand bed is upon initial start up. If installed incorrectly the pressure loss across the filters may be excessive, up to 10 - 25 psi instead of the normal 3 - 5 psi. The following steps should be taken during setup:

- Order prewashed gravel.
- Wash the gravel on site as even prewashed gravel can be dirty upon arrival after shipping.
- Install the gravel and sand media to the depths specified by the manufacturer.
- Close all valves including the backflush valves. Make sure the valve to the irrigation system is closed.

- Open the backflush valve to one of the media tanks very slowly. Then open the backflush adjusting valve slowly but do not exceed the maximum backflush flow rate. See next section on backflush adjustments. This ensures that the water is flowing slowly through the other media tanks that are in filtration mode, thus preventing downward migration of fine particles that could plug the underdrain.
- Close the backflush valve on the first tank and repeat the procedure for the other tanks.
- Repeat the entire procedure again to ensure that the media is clean before opening the valve to the irrigation system.

To ensure effective operation of a sand media filter also consider:

- The filter capacity should exceed the system flow demand.
- The filtration capability should match the requirements of the emitter types to be used.
- The filter should be located to allow access for maintenance, cleaning and disposition of backflush and rinse water.
- The filter should be installed after the chemical and fertilizer injectors. Chemical precipitates that form during injection can then be collected by the filter system.
- A coarse screen should be installed before the sand media filter on systems where large trash removal is required.
- Flow meters and pressure gauges should be installed to monitor system performance over time. These components are integral to not only checking filter performance but also the overall trickle irrigation system performance.
- A backup screen should be installed after the sand media filter to prevent sand from entering the trickle system due to filter malfunction or incorrect operation.

Some operators have screens installed at the beginning of each lateral although this should not be necessary if the filtration system is performing properly. See Figure 10.16. However, should a mainline or submain break inline screens may be beneficial.

*Figure 10.16* *In line Screens*

## Backflush Adjustments

The backflush flow rate must be sufficient to expand the media bed, allowing organics and other small particles with a lighter specific gravity than the media sand to be carried out by the backflush water.

*Figure 10.17* *Backflush Water from a Sand Media Filter*

A valve on the backflush discharge line should be used to adjust the flow rate so that just a slight trace of media sand exits with each backflush. Higher flow rates will remove too much media and lower flow rates will not ensure an adequate backflush. Table 10.9 provides a guide to backflush flow rates.

A flow control valve can be used to regulate flow if it can be matched to the manufacturer's recommended backflush flow rate. A better method is to have a valve that can be adjusted to the field conditions that will exist when backflushing is to occur. The correct procedure for manual backflushing is as follows:

- Turn off the flow to the irrigation system so that maximum pressure is available.
- Open the valve on the backflush line in small increments.
- Check the water discharging from the backflush line for the presence of media sand. A nylon sock or 100 mesh screen can be used to capture the material.

- Increase in small increments until a small presence of sand is found. Remove the handle from the valve so it cannot be inadvertently changed.

The discharge line should be short, run downhill and be easily accessible for testing.

## Automatic Backflush Operation

Automating a sand filter to backflush as needed will eliminate problems associated with changing water qualities and human error such as forgetting to backflush or backflushing for incorrect durations. A problem associated with automatic backflushing is ensuring that there is sufficient pressure to perform an adequate backflush and that the time taken to complete the backflush is sufficient.

Points to consider for automating sand media filters include:

- The automatic backflush should use both a differential pressure switch trigger and an elapsed time trigger. The pressure differential trigger should be set for 5 to 7 psi over the clean filter pressure difference. The actual pressure difference set on the trigger may therefore be 8 to 14 psi. Check the clean filter condition first before setting the trigger level. The elapsed time trigger should be set for one backflush per day.

  *This is very important to prevent small particles of sand from working down through the sand bed and slowly plugging up the bottom of the sand media filter. This can happen slowly without the operator observing a large change in pressure differential. Backflushing frequently will prevent this from occurring.*

- Automatic systems should have a dwell time adjustment that allows the system pressure to build up so that each tank has the same pressure for backflushing. The backflush valve from one unit should be closed before the other unit's backflush valve is opened.

- Another method to ensure sufficient pressure and flow are available for backflushing is to install a solenoid valve on the discharge line to the irrigation system. This valve would be set up to close automatically each time a backflush is initiated. Table 10.7 provides a guide to flushing flow rates that are required for different sand medias.

- Testing should be done periodically to ensure that the backflush duration is adequate. The backflush water should be clear at the end of the backflush cycle.

## Sand Media Selection

Filter sand is classified by mean effective size and a uniformity coefficient.

**Mean Effective Media Size** – Refers to the size of the smallest 10% of the particle sizes that will form the media bed. An effective size of 0.80 mm means that 10% is finer than 0.80 mm.

**Uniformity Coefficient** – Is an index that describes the variability of particle sizes in a sample. It is a ratio of an opening size that will pass 60% of a representative sample of sand divided by the opening that will pass 10% of the same sample. A value of 1 indicates that all the particles are the same size. A uniformity coefficient of 1.5 is required for trickle irrigation filter sand grades.

The two basic materials that should be used in trickle irrigation sand media filters are sharp, crushed silica sand or sharp, crushed granite. Good media should have angular rather than rounded particles. Selecting the sand grade required for the various emitter types can be determined from Table 10.3.

A comparison of the sand media filtrative capacity vs an equivalent screen mesh is given in Table 10.7. A sand media uniformity coefficient of 1.5 must be obtained before the screen mesh designation shown will be reached. Sand media has a range of filtration capabilities due to varying particle sizes. To be safe a value in the middle of the range should be used. Table 10.7 can be used to select the filter media once Equations 10.1 or 10.2 have been used to determine the degree of filtration required for the emitter used.

**Table 10.7 Comparison of Sand Media Filter and Screen Mesh Equivalent**

| Sand Media Designation | Mean Effect Media Size mm | Screen Mesh Equivalent |
|---|---|---|
| #8 crushed granite | 1.5 | 100 - 140 |
| #12 silica sand | 1.2 | 130 - 140 |
| #11 crushed granite | 0.78 | 140 - 180 |
| #16 silica sand | 0.7 | 150 - 200 |
| #20 silica sand | 0.47 | 200 - 250 |

## Sizing a Sand Media Filter

Proper sizing of a sand media filter must consider the filtration rate as well as the backflush flow rate. The following guidelines should be used:

- The recommended filtration rate for average quality water is 20 gpm / $ft^2$ of sand bed area.
- If the supply water is excessively dirty, (> 50 mg/L suspended solids) the flow rate should be reduced to 10-15 gpm / $ft^2$ of sand bed area to increase the filtration capacity. At these low flow rates the filters should be backflushed at least once a day to prevent dirt from moving to the bottom of the sand bed. Dirt moves down deeper into the sand beds at low flow rates without causing an increase in pressure difference. Automatic backflushing may therefore not occur in time.
- Recommended backflush flow rates are shown in Table 10.9. These flow rates are required to ensure sufficient flow is available to properly lift the sand beds to allow for a good backflush. For filter stations that are designed at lower flow rates of 10 - 15 gpm /$ft^2$ of bed area, three separate filters may be required to ensure sufficient flow is available for a good backflush. A flow control valve installed on the backflush line can be used to regulate the backflush flow rate and control the amount of media expelled during backflush.
- Filter stations with 3 or 4 units may be required if the sand filter is set to backflush automatically while the irrigation system may be operating.

The filters that are not being backflushed must be able to filter the irrigation system demand and the backflush flow rate of one sand filter. Enough units must be on line to keep the filtration rate at less than 30 gpm / ft$^2$.

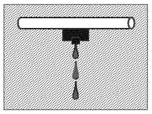
**Table 10.8 Steel Media Tanks Specifications**

| Tank Configuration | Filtration Area ft$^2$ | Recommended Maximum Working Pressure psi |
|---|---|---|
| 2 - 18" | 3.5 | 125 |
| 3 - 18" | 5.25 | 125 |
| 2 - 24" | 6.25 | 125 |
| 3 - 24" | 9.5 | 125 |
| 2 - 30" | 9.8 | 110 |
| 3 - 30" | 14.8 | 110 |
| 2 - 36" | 14.2 | 100 |
| 3 - 36" | 21.2 | 100 |
| 2 - 48" | 25.0 | 80 |
| 3 - 48" | 37.5 | 80 |

**Table 10.9 Minimum Backflush Flow Rates for Sand Media**

| Sand Designation Number | Minimum Backflush Flow Rate gpm / ft$^2$ |
|---|---|
| # 8 Crushed Granite | 16 |
| # 11 Crushed Granite | 15 |
| #16 Silica Sand | 18 |
| #20 Silica Sand | 15 |
| #30 Silica Sand | 13 |

**Example 10.4 Sand Filter Size Calculation**



The point source emitter system example uses two 2 L / hr emitters per plant. The orifice size for the emitter is 0.030 inches. The surface water source has an organic loading of 10 mg /L. A sand media filter is required. The flow rate for the system is 110 gpm. The sand media filters are to backflush automatically while the irrigation system is operating. Select the media grade that is required, the filter tank size and the number of tanks.

Using Equation 10.1

$$\text{The } MFC_d = \frac{0.03 \text{ inches}}{10} = 0.003 \text{ inches}$$

*(Continued)*

**Example 10.4 Sand Filter Size Calculation** *(Continued)*

Determine Mesh Size:
From Table 10.1
The mesh equivalent to filter out 0.003 inches is 200 mesh.

Determine Sand Bed Area:
From Table 10.7
To achieve a 200 mesh equivalent rating, # 16 silica sand is selected as the sand media. The organic loading of the water is not excessively high so a filtration rate of 20 gpm /ft$^2$ will be used.

$$\text{The sand bed area required is: } \frac{110 \text{ gpm}}{20 \text{ gpm / ft}^2} = 5.5 \text{ ft}^2$$

Tank Configuration:
From Table 10.8
Three 18” sand filters or two 24” sand filters will be able to provide the level of filtration required. The filtration area of each 18” unit is 1.75 ft$^2$. The filtration area of the 24 “ units is 3.12 ft$^2$.

Backflush Flow Rate:
From Table 10.9
The backflush flow rate for #16 silica sand is 18 gpm /ft$^2$ of bed area.

Using the 18 inch units the backflush flow for one 18” sand filter would be:

$$1.75 \text{ ft}^2 \times 18 \text{ gpm / ft}^2 = 31.5 \text{ gpm}$$

Since the filters are backflushing automatically, the flow rate through the other two 18“ sand filters (3.5 ft$^2$) must meet the irrigation demand and the backflush flow rate of the one filter. The flow rate through the other two filters is:

$$= \frac{110 \text{ gpm} + 31.5 \text{ gpm}}{3.5 \text{ ft}^2} = \frac{141.5 \text{ gpm}}{3.5 \text{ ft}^2} = 40 \text{ gpm/ft}^2$$

The recommended maximum flow rate is 30 gpm/ft$^2$. To achieve this flow rate additional filters must be added. If four 18” filters are used the flow rate through three filters (5.25 ft$^2$) while the other one is backflushing will be:

$$= \frac{110 \text{ gpm} + 31.5 \text{ gpm}}{5.25 \text{ ft}^2} = \frac{141.5 \text{ gpm}}{5.25 \text{ ft}^2} = 27 \text{ gpm/ft}^2$$

Four 18” sand media filters with #16 silica sand is recommended for this automatic filtration station.