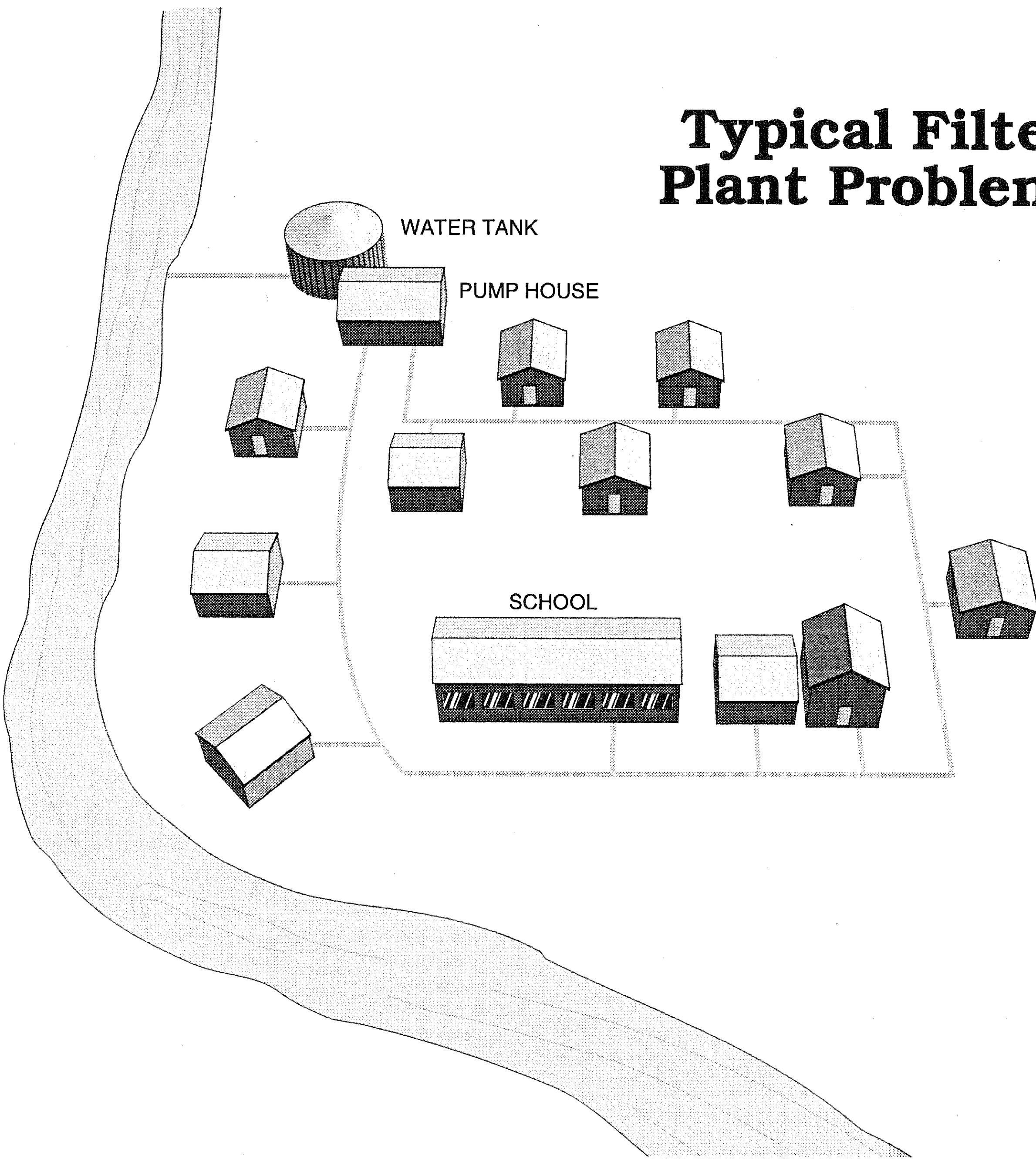
O & M of Small Water Systems



Typical Filter Plant Problems

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O & M of Small Water Systems

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TYPICAL FILTER PLANT PROBLEMS

WHAT IS IN THIS MODULE?

1. Typical coagulation problems associated with cold water.
2. Causes and solutions to filter breakthrough including; high suspended solids, inadequate flocculation, filter cracking, mudballs, gravel mounding, and filter clogging.
3. Causes and solutions to negative head and air binding.
4. Causes and solutions to bacterial growth in a filter bed.
5. How to check filter bed expansion.
6. How to test for mudballs.
7. Typical alum problems and suggested solutions.

KEY WORDS

- Breakthrough
- Coagulation
- Floc
- Polyelectrolytes
- Suspended solids
- Mudballs
- Turbidity
- Head
- Cationic
- Anionic
- MCL
- Alum

MATH CONCEPTS DISCUSSED

- Filtration rates
- Percent by volume
- Hydraulic expansion
- Raise rates
- Backwash rates
- TDH
- Conversion of head to psi

SCIENCE CONCEPTS DISCUSSED

- Coagulation
- Chemical cementing
- Cold temperature impact on chemical reaction time

SAFETY CONSIDERATIONS

- Confined space
- Working over water
- Handling chemicals

MECHANICAL EQUIPMENT DISCUSSED

- Gravity Filters
- Pressure Filters
- Headloss gauges
- End-suction centrifigual pumps

TYPICAL PLANT PROBLEMS

The following material was adapted from a Canadian publication titled "Surface Water Treatment Workshop Manual" dated 1974 and produced by the Ministry of the Environment, Ontario.

COAGULATION - PROBLEMS

COLD WATER

Below 40°F

When the raw water temperature drops below 40°F many water treatment plants operating near capacity begin to experience a variety of problems. The cold water slows down the rate of the coagulation reaction and flocculation. The result is usually small floc that does not settle readily.

Floc Carry Over

This results in a floc carry-over from the sedimentation system to the filters. This could impact the filters in the following ways:

1. The filter runs may be shortened due to the increased solids loading.
2. The filter may break through; that is, at headloss far below terminal, the effluent turbidity will suddenly increase. Typically, the filter effluent turbidity is nearly equal to the settled water turbidity before filtering. The only quick solution is to backwash the filter.

Lack of Alarms

Unless the plant is equipped with high turbidity shutdown and alarms the clearwell water quality will deteriorate. The material breaking through the filter can carry high concentrations of microorganisms.

3. The finished water will often contain a high residual aluminum content. The high aluminum residual may be due to filter breakthrough and/or delayed reaction time resulting from the cold water.

Results

The results of high aluminum, besides the health implications, are floc formation in the distribution system resulting in increased customer complaints and coating of pipelines thus reducing their capacity.

COAGULATION AIDS FOR COLD WATER

Activated Silica

Sodium silicate can be activated by a number of chemicals including sodium bicarbonate and chlorine. The activated silica when used in conjunction with alum produces a bigger, tougher floc.

The activated silica molecule, a negatively charged, long chained polymer structure, acts as a bridge between floc particles.

Advantages

Some of the advantages of activated silica are:

- improved quality of filtered water.
- Broader pH range of treatment.
- Good flocculation of water whose quality changes over a wide range, including spring runoff from heavy rains.
- Increased compaction of sludge.
- Longer filter runs.
- Use of higher filtration rates.
- Reduced chemical cost.
- Increased plant capacity.
- Helps to reduce the residual aluminum content of the filtered water, thus preventing "after floc" problems.

POLYELECTROLYTES

Polyelectrolytes (polymers) consist of long chains of carbon atoms. Like activated silica, polymers help to produce a superior floc in difficult situations. There are three classes of polymers

- Non-ionic - no charge
- Anionic - negatively charged
- Cationic - positively charged

NON-IONIC POLYMER

If the plant is experiencing slow growth floc (it takes a long time for the floc to form) or small floc that does not settle properly, the floc growth may be aided by a non-ionic polymer.

FILTRATION PROBLEMS

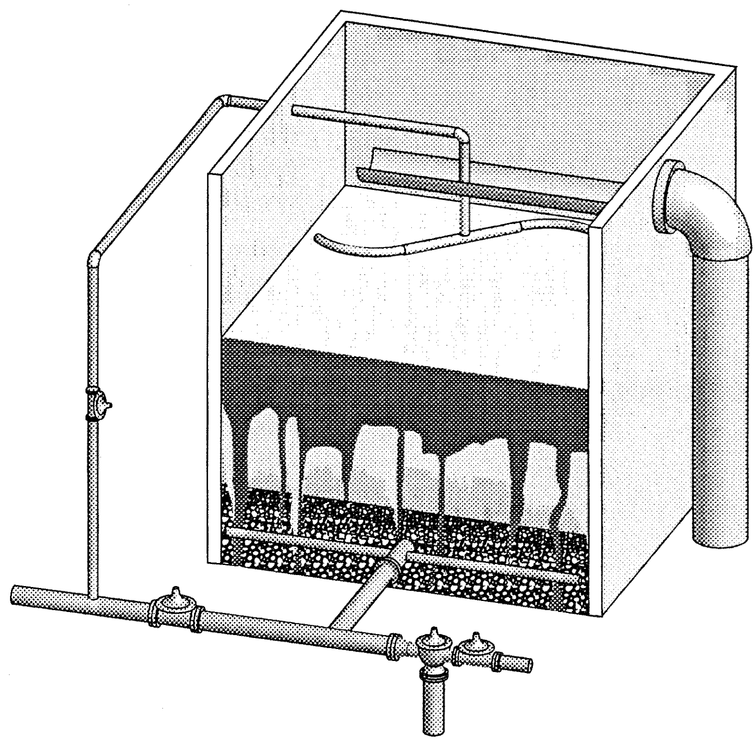
FILTER BREAKTHROUGH

Definition

One of the most common water treatment problems is filter breakthrough prior to terminal headloss. Breakthrough may be defined as a steady increase in filter effluent turbidity or color as the filter time progresses.

Under normal operation, the turbidity will remain relatively constant until the filter reaches terminal headloss (typically 8 ft). If breakthrough occurs, there is a steady increase in effluent turbidity. The slope of the effluent turbidity line will be steeper if the raw water turbidity increases or the filtration rate is increased.

If breakthrough occurs on a regular basis, the following problems can result:



1. Treated water turbidity may exceed the MCL.
2. There may be a loss or reduction of chlorine residual in the distribution system.
3. There is the possibility of increased bacterial growth in the distribution system.
4. The tap water containing floc will increase customer complaints.
5. A buildup of suspended matter causing constant maintenance of water meters and control valves.

6. Fire hydrant operating mechanisms may be clogged.
7. Corrosion an increase in red water formation.
8. Increase in taste, odor and color complaints.
9. Coagulant may foul some industrial processes.
10. Reduction in pipeline capacity.

Needless to say, these problems should be prevented so that the customer is provided with water of acceptable quality.

Causes

Breakthrough may be caused by one or more problems. The following is a listing of the most common causes;

- High suspended solids
- Inadequate flocculation
- Filter cracking
- Mudballs
- Gravel mounding
- Filter clogging

HIGH SUSPENDED SOLIDS

Causes

Suspended solids can be defined as suspended matter in the raw water plus the added coagulant(s).

For plants using sedimentation basins, high suspended solids entering the filter are usually due to:

- Incorrect dosage of coagulant or coagulant aid.
- Hydraulically overloaded flocculation and sedimentation basins.

Operating Characteristics

As a filter continues to trap suspended particles in the media the headloss increases. The suspended matter is usually trapped in the upper half of the filter bed. As the filter run time increases the solids penetrate deeper into the bed. The objective of the operator is to have the filter reach its terminal headloss prior to the solids entering the bottom layer of the media.

High Floc

If the settled water contains an increased level of floc there will be too many floc particles competing for deposit sites within the filter bed. In extreme cases the solids may be driven through the media into the underdrain prior to the filter reaching terminal headloss. The reasons that the filter did not reach its terminal headloss before breakthrough may include the following:

- The floc was weaker than usual due to constant collisions of other floc particles during flocculation.

- The large volume of floc in the upper layers of the filter bed promote channeling early in the filter cycle.
- The floc is broken up within the filter bed because of the constant collisions of floc particles during their competition for deposit sites.

Whatever the reasons, if the conditions of high suspended solids entering the filter persists, the plant operation will be severely restricted.

Remedies

Filter breakthrough can be eliminated in most sedimentation basin systems with proper pretreatment. This means the addition of the correct dosage of primary coagulants and coagulant aids. If the system is overloaded hydraulically, it becomes like a direct filtration system. In this instance, polymer should be added at the filter to strengthen the floc. The stronger floc will be trapped higher in the filter bed and the filter should reach terminal headloss prior to breakthrough.

INADEQUATE FLOCCULATION

Causes

In most cases, inadequate flocculation is caused by improper dosages of chemicals, inadequate mixing, or in some cases the wrong chemical being used.

Characteristics

Underdosing alum will lead to fine particles of unagglomerated turbidity or color particles passing through the filter. In some cases, the filter will work sufficiently well for a short period of time but premature breakthrough will occur at a low headloss. Overdosing alum will lead to high suspended solids in the effluent. If mixing is inadequate or the velocity through the valves and piping leading to the filters is too high (greater than 1.2 ft/sec) a weak or fractured floc may be formed and filter breakthrough may occur at a low headloss.

Remedies

Adding the correct dosage of coagulant and coagulant aids should always take place. The use of jar tests should become a common plant practice. If flocculation is producing a weak or inadequate floc, experts should be consulted to provide the solution to this problem.

FILTER CRACKING

Causes

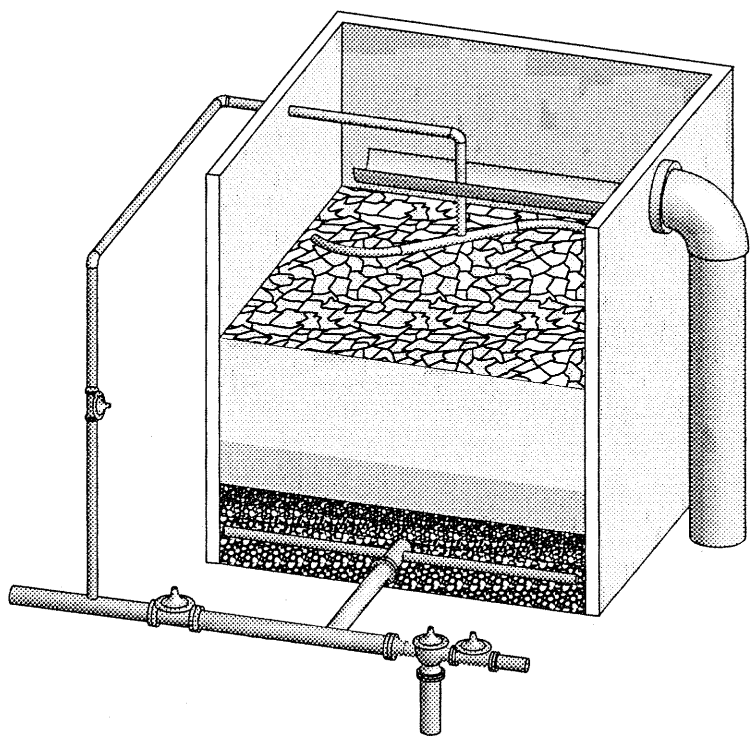
Filter cracking is usually due to the filters being run an excessively long time between backwashes. A faulty headloss device may result in the filters being operated too long.

Characteristics

As filter run time increases, suspended matter builds up in the upper part of the media. If the filtration rate is too low or the top of the filter media has too small of openings the particles will not penetrate the bed, and a cake forms on the surface. This cake causes a high headloss across the bed. Under certain hydraulic conditions, the cake will crack and water containing suspended matter will be channeled through the bed into the clearwell.

Remedies

If cracking is a common occurrence, a revised schedule of backwashing should be undertaken. All headloss devices should be checked and maintained in proper working order. The media should be examined for possible deposits and/or coatings of foreign material. It may be necessary to sample and size the media and replace it if it is found to be too small.



MUDBALLS

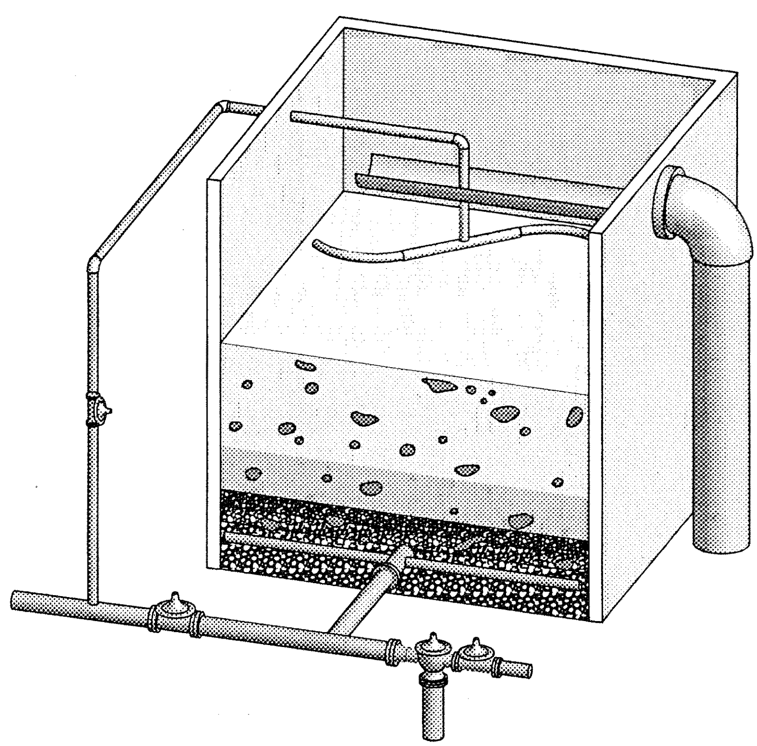
Causes

Mudballs are common in many plants but quite often their presence is unknown to the operator. They can be caused by low backwash rates which will result in a failure to remove much of the suspended matter trapped in the bed. Also, the lack of either surface washers or air scour assistance prior to backwash can promote mudball growth.

Characteristics

Mudballs often look like small pancakes. Their size can range from a fraction on an inch to several inches. If the surface wash device is not working or low backwash rates are used (less than 15 gpm/ft^2 @ 50°F for sand or dual media) the floc will coat or combine with some media particles and remain on the surface of the bed. After repeated washes, the particles will grow in size and weight. Over several weeks, they will penetrate the bed gradually and come to rest near the supporting rock or the last layer of media.

They can prevent the plant from producing the best possible water due to their destruction during the filtration cycle. (e.g. when the filter is clean the effluent should be less than 0.1 ntu . Mudballs, because they deteriorate and go into the effluent may raise the turbidity to 0.4-0.5 ntu.) Mudballs will also reduce the effective filter area causing a very high filtration rate in other areas of the filter thus, promoting breakthrough.



Remedies

Mudballs are easier to prevent than remove. Keeping the surface wash or air scour devices in top operating condition is a necessity. Adequate backwash must be provided at all times. Expert help should be sought if the backwash rates are found to be inadequate.

All filters should be checked at least once a year for mudballs.

The removal of mudballs is done by hand. The filters have to be dug up and the mud removed. Chemical means are time consuming, inadequate, and costly.

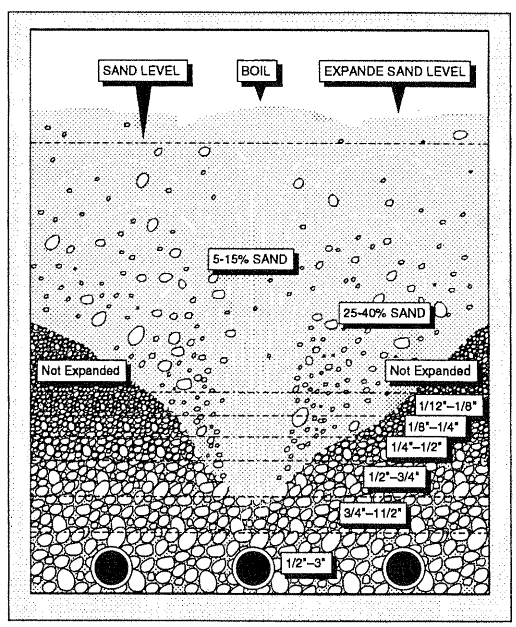
GRAVEL MOUNDING

Causes

Gravel mounding is where there is uneven and intermixed layers of filter media. Mounding is often caused by "surge backwashing" which means that the backwash water is allowed to enter the underdrain area too quickly. The media is "blown" into other parts of the filter area. Although sand and coal will separate after mixing, damage done to the gravel layer is permanent. This problem sometimes is due to clogged or corroded underdrains diverting the backwash water into certain areas of the gravel.

Characteristics

If the gravel is blown up into the media, there will be less resistance to the flow of flocculated water in that area. This short circuiting will result in the flocculated water passing through the mounded portion of the bed at filtration rates higher than the average filter flow. This may lead to early filter breakthrough. In addition, inadequate backwashing will take place and mudball formation is likely. The media depths of a filter can be found by using a probe (long pole with a disk on the end) and using a low backwash rate sufficient to suspend the filter bed.



Remedies

The probe method, described above, is one of the best techniques available to determine if the gravel has shifted. If the gravel has shifted, the filter should be partially dug out and examined to determine if the coarser grades have been moved. If only the finer grades have moved the problem is not serious and can be corrected by raking of the gravel layer during slow backwash or by adding extra gravel to the low spot. If the coarser gravel has shifted, the complete removal of the gravel layer will probably be necessary. A close examination of the underdrains should also be undertaken. Expert help should be consulted if the reason for the mounding is not apparent or if the underdrain system needs to be replaced.

Yearly probe tests should be part of your regular maintenance program.

FILTER CLOGGING

Causes

Filters can become clogged if diatoms are present. This microscopic form of plant life seals the surface of the filter media and may lead to filter cracking and severe channeling if the headloss device does not work properly.

The filter could also be prone to clogging if the media becomes encrusted with calcium carbonate. Calcium carbonate deposits may occur with the improper use of pH corrective chemicals. (e.g. a highly localized concentration of sodium hydroxide). Calcium carbonate deposits may also occur in lime softening plants where the floc carry over coats the filter media.

Characteristics

Incrustation on the filter media and the appearance of calcium carbonate on individual media particles. It may result in channeling through the filter bed causing breakthrough. A high initial headloss through the freshly washed filter may be characteristic of chemical incrustation.

Diatoms in sufficient numbers result in shorter than normal filter runs.

Remedies

Diatoms can best be removed through the proper use of microstrainers or sedimentation. Shorter backwashes than usual to minimize the strain on the backwash facilities may also have to be employed.

Chemical cleaning of filter media encrusted with calcium carbonate may be necessary. It would not be advisable to use chemical means to clean the media without expert advice as permanent damage could be caused.

MEDIA BREAKTHROUGH

Causes

Most of the underdrains with the exception of the alloxite plates are usually found with graded layers of filter gravel separating them from the bottom of the filter media layer. The orifices in these types of systems range from 1/8 to 5/8 of an inch.

Normally the graded gravel supports the filter bed, and distributes the flow in the filtration and backwash cycles. If mounding occurs, it is possible for some of the filter media to pass through the orifices in the clearwell and possibly into the distribution system.

Metal nozzles and strainers will corrode over the years. In some systems, the plugged orifices will cause an excess of water to be passed through non-plugged holes and mounding may occur. In other systems, the corroded nozzles may be eaten away and the majority of the flow passes through this area. Although plastic nozzles do not corrode, it is possible for them to crack wear or be broken during probing the filters.

Characteristics

Media breakthrough can cause improper seating of valves, foul up water meters, and on occasion can plug fog-nozzles employed for fire fighting.

Remedy

If you should suspect that filter media is passing through a filter, install sample taps on the filter effluent lines and attach socks to each tap. When the sample taps are opened all the water will pass through the socks and the media will be caught in the sock.

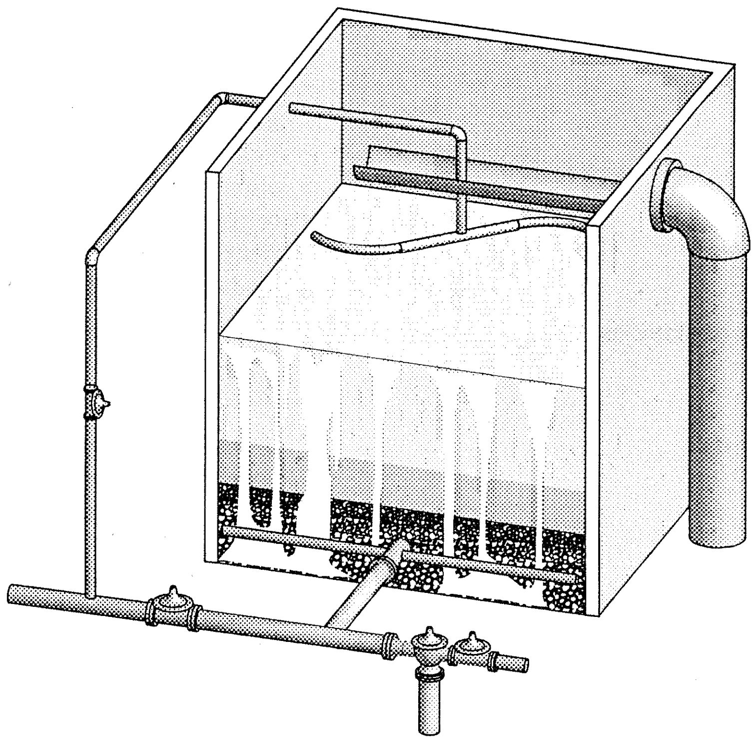
It is imperative that media breakthrough be stopped quickly. In most cases, the underdrain system has to be replaced. If the cause of the problem cannot be readily detected, expert help should be summoned.

OTHER PROBLEMS

NEGATIVE HEAD AND AIR BINDING

Cause

Some filtration plants have only 4 to 5 feet of water above the media surface and air binding problems may occur occasionally. Air dissolves in water at or near the saturation point. When the pressure is reduced to less than atmospheric pressure below the surface of the media, air comes out of solution and air bubbles accumulate within the media.



Characteristics

This may result in a marked increase in the headloss. If the operator is not aware of this problem, media may be lost in the early part of the filter backwash due to the violent agitation of the air being released from the filter media. This problem often occurs in the spring when the water temperature warms and the water is supersaturated with air.

Remedy

To prevent the loss of media, care should be taken at the beginning of the backwash to partially drain the filter below the overflow troughs prior to starting the backwash water pumps.

TEMPORARY BREAKTHROUGHS

Causes

Often in the routine operation of the plant, the operator will find that the water demand fluctuates and it is necessary to change the filtration rate. Depending on variables such as the solids entering the filter box, filtration rate changes etc., this surge of extra water through the filter will pull more solids into the clearwell. In one example, a filter was in operation for 13 hours. During this time the effluent turbidity rose from 0.1 to 0.4 ntu. After it recovered to 0.1 ntu, the filter rate was then increased again at hour 20, and the turbidity rose to 0.5 ntu. This rise in the turbidity after filtration rate change can be severe enough to cause a marked deterioration in the water entering the distribution system.

Remedies

If possible, the filtration rate should be held as steady as possible through the length of the filter run. In a multi-filter operation, this may necessitate the shutting down of one or more filters during periods of low demand and returning them to service as the demand warrants their use. If this technique is not possible, the change in the filtration rate should be kept to a minimum. For example, if high demands are expected near the supper hour increase the filter rate an hour before the increase in demand and raise it slowly through the high demand period. This way, the amount of high filter effluent turbidity entering the distribution system can be minimized.

BACTERIAL GROWTH WITHIN THE FILTER BED

Cause

If prechlorination is not practiced, bacterial growth may occur, clogging the filter bed. One effective method of cleaning up such a bed is heavy chlorination.

Needed Equipment

The apparatus needed is a portable chlorinator, a 100 or 150 pound chlorine cylinder and a hand operated piping arrangement which is thrust down into the bed. The piping assembly is made up of a piece of one inch piping about six feet in length having a tee fitting at both ends. Two short lengths of one inch pipe about 14 inches long are threaded into the tee at one end of the six foot section. The outer ends of these are capped and a number of small holes are drilled through each length. This is the end of the assembly which is push down into the filter media for chlorination. To the opposite end of the assembly two more short lengths of pipe are fixed to form a handle. The outer end of one pipe is capped as before and the other end is fitted to take on a one-inch hose connection.

CALIBRATION OF FILTRATION RATES

Use of this procedure

This procedure can be used to verify the filtration rate or the filter to waste rate. The only difference is in which valves are opened.

Equipment Needed

1. Stopwatch
2. Staff gauge marked off in feet and tenths of feet
3. Note pad and pencil

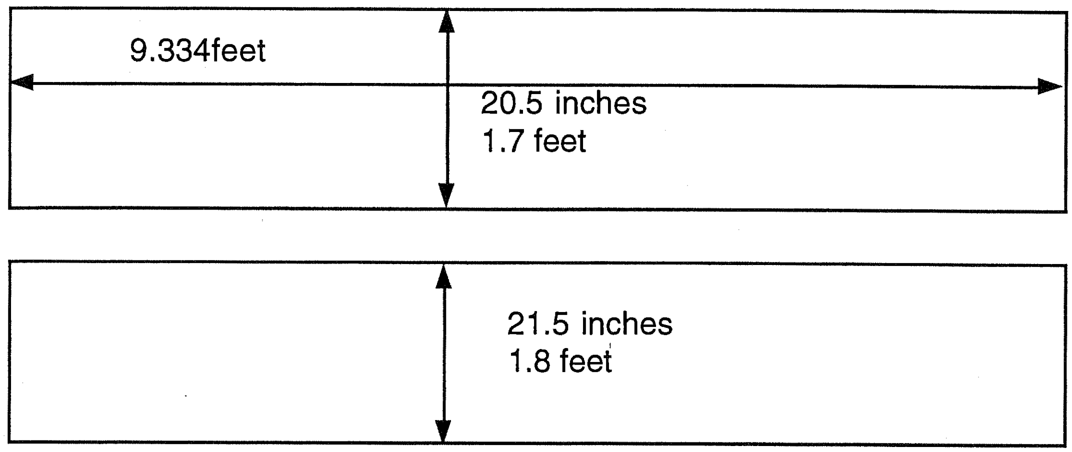
Procedure

1. Insert the staff gauge in the filter basin. Secure it to the wall.
2. Shut off the influent valve to the plant.
3. Open the filter to waste valve.
4. Wait until the water level has dropped enough so that no water is running into the launder through the bolt holes used to secure the weirs to the launders.
5. Note the water level and start the stop watch.
6. Wait for the water level to drop a precise distance. Typical distances are 3, 4 and 6 inches (0.25, 0.33 and 0.5 feet) *Do not measure more than a 6 inch drop. As the head over the filter drops, the filtration rate will decline.*
7. Read the staff gauge. Stop the stop watch and read the time.
8. Return the plant to normal operation.
9. Calculate the volume of water filtered.
10. Calculate the flow rate in gpm.
11. Divide the flow rate in gpm by the surface area of the filters.

Example:

The following data was gathered at a water treatment plant. The water was not allowed to drop below the launder and therefore the volume of water filtered will be calculated by determining the water loss from each side of the launder. The launder was located between the two surface areas shown below.

Plan view of filters



Data

Drop of 4 inches in 1 min 18 sec

Calculations

Determine area of the water drop.

- 1.7' X 9.334' = 15.96 ft^2
- 1.8' X 9.334' = 16.73 ft^2
- Total surface area of filter areas = 32.69 ft^2

Convert the distance the water dropped to feet.

- 4" / 12" per foot = 0.333 ft

Determine the volume in cubic feet.

- 32.69 ft^2 X 0.333 ft = 10.88 ft^3

Convert the volume in cubic feet to gallons.

- 10.88 ft^3 X 7.48 gpm/ft^3 = 81.43 gal

Convert the time data to minutes.

- 1 min 18 sec = 78 sec ; 78 sec/ 60 sec/min = 1.3 min

Determine the filtration rate in gpm.

- 81.43 gal/ 1.3 min = 62.6 gpm

The filter surface is 46.7 ft^2. Determine the flow rate of the filter.

- 62.6 gpm/46.7 ft^2 = 1.34 gpm/ft^2

CHECKING FILTER BED EXPANSION

Two tests

One of the quick methods of determining proper backwash rates is to check filter bed expansion.

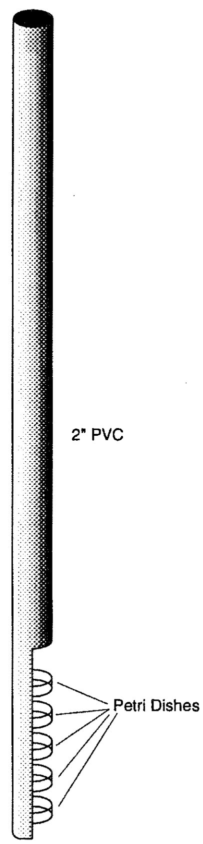
Normal Conditions

Normal filter bed expansion during backwash is 20 to 35% physical expansion. For example if the filter bed were 47 inches in depth, the bed should rise between 9.4 and 13.5 inches.

BED EXPANSION

MATERIALS NEEDED

Use an 8 foot length of 2 inch PVC. Cut the PVC vertically for two feet. Glue a 2" plastic petri dish every 3 inches for the first 15 inches of the half pipe.



DIRECTIONS

Insert the PVC media rise measuring device into the filter bay. The bottom of the device should set on top of the filter media. Secure the device to the filter bay wall.

Start normal backwash.

After backwash gently remove the device, being careful to keep it in a vertical position.

Observe and record the highest level that you can observe media.

CALIBRATION OF BACKWASH RATES

Use of this procedure

This procedure can be used to verify the backwash rate or the filter to waste rate. During start-up the backwash rate was verified and that information is shared here.

Equipment Needed

Stopwatch

Staff gauge marked off in feet and tenths of feet

Note pad and pencil

Procedure

1. Insert the staff gauge in the filter basin. Secure it to the wall.
2. Shut off the plant influent.
3. Allow the filter to drain down until there is only 1 foot of water above the media.
4. Shut off the surface wash arm water supply. This is done by closing the ball valve on the surface wash arm supply.
5. Start the backwash pump. *It may take one full minute for the backwash pump to reach full flow.*
6. When the water level reaches the bottom of the launder the valve should be fully open. If so read the staff gauge and start the stop watch.
7. When the water level has reached the top of the weirs and is about to go into the launder. Read the staff gauge and stop the watch. Note the time.
8. Allow the plant to proceed with a normal backwash cycle and return to normal operation.
9. Calculate the volume of water between the bottom and the top of the launder.
10. Calculate the flow rate in gpm.
11. Divide the flow rate in gpm by the surface area of the filter.

Example:

The filter used in the filtration rate procedure, described above is used for this example.

Data Collected

There was a 1 foot rise in 22.7 seconds. This rise started at the bottom of the launder.

Calculations

Determine the volume in cubic feet.

- $32.69\ ft^2 \times 1\ ft = 32.69\ ft^3$

Convert the volume to gallons.

- $32.69\ ft^3 \times 7.48\ gal/ft^3 = 244.52\ gal$

Determine the flow based on the observed rise time.

- $244.52\ gal/22.7\ sec = 10.77\ gal/sec$

Convert the backwash flow from gal/sec to gpm.

- 10.77 gal/sec X 60 sec/min = 646.3 gpm

Determine the backwash rate.

- 646.3 gpm/46.7 ft^2 = 13.84 gpm/ft^2

AWWA/B100-80

The following table was taken from the AWWA Standard on Filtering Material B100-80.

Maximum Backwash Rates

Water Temperature, ° F	Maximum Backwash Rate, gpm/ sq ft
50 or less	15
51- 55	16
56- 60	17
61- 65	18.5
66 - 70	20
71-75	21
Above 75	22.5

Observations During Backwash

This procedure was conducted during start-up using a slightly cruder device. However, the media rise was less than six inches.

CALIBRATION OF BACKWASH PUMP TDH

TDH Defined

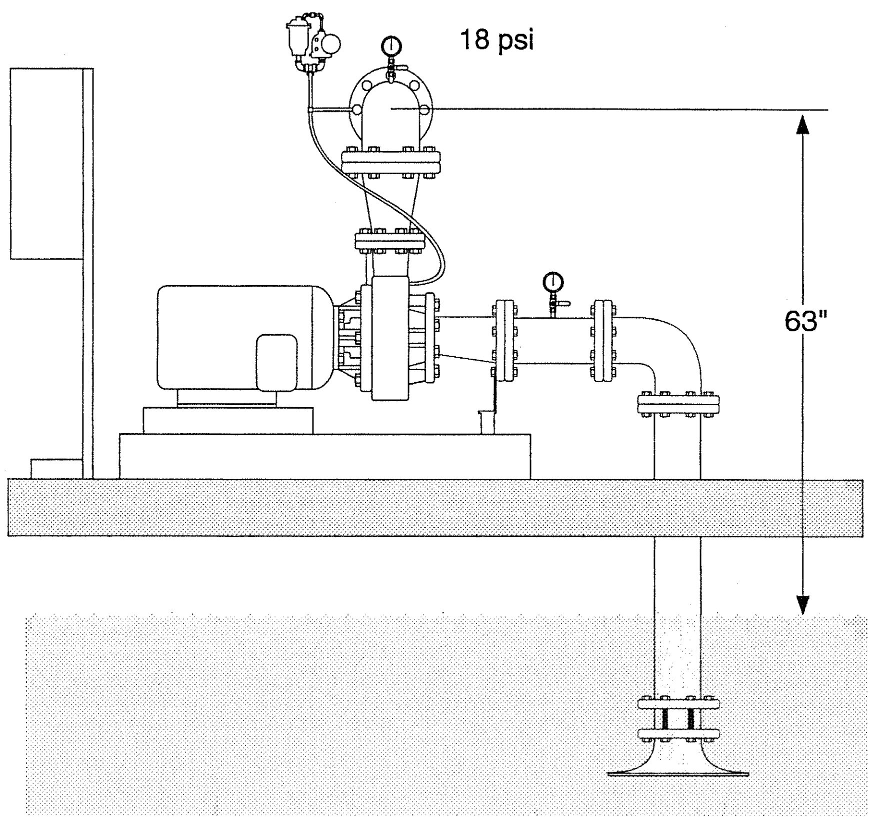
TDH (Total Dynamic Head) of a pump is the difference in the elevation between two water levels (elevation head) plus head loss in the suction and discharge lines plus velocity head. The following procedure can be used to determine the TDH of an existing end-suction centrifugal pump, in a suction lift condition.

Example:

TDH for Backwash pump

In our example plant, the backwash pump is an end-suction centrifugal pump in a suction lift condition. Therefore, TDH is merely a matter of determining the pump discharge pressure, converting that to feet and adding the distance from the center of the discharge line to the top of the water in the clearwell.

Data Collected



Calculations

Convert the discharge pressure to feet of head.

- 18 psi/0.433 psi/ft = 41.57 ft

Convert the distance from the center of the discharge pipe to the water level in feet.

- 63 inches / 12 inches per foot = 5.25 ft

Determine TDH.

- 41.57 ft + 5.25 ft = 46.8 TDH

Comparison with Curve

According to the pump curve, with an 8.5 inch impeller and a TDH of 48 feet, the flow should be 780 gpm. This pump is from our example plant described above. The calculated backwash rate was 649 gpm. The most common problem associated with this type of situation, is an incorrect pump impeller diameter.

Shutdown Head

The shutdown head on this pump was tested at 29 psi.

Convert this pressure to feet of head.

- 29 psi /0.433 psi per foot = 67 feet

Add the distance between the discharge line and the water level and determine TDH at shutdown.

- 67 feet + 5.25 feet to water level = TDH of 72.25 feet

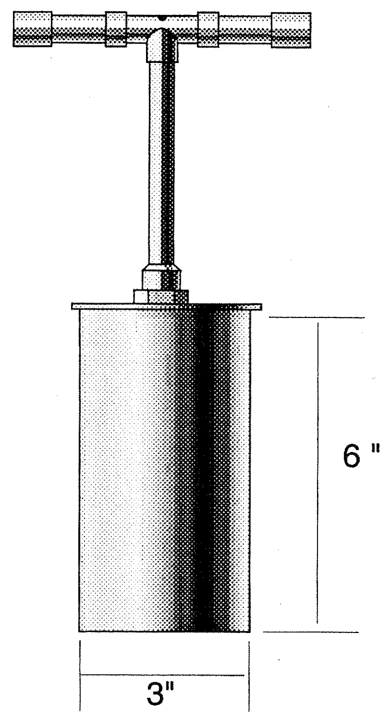
MUDBALL TEST

REFERENCE READING

Water Quality and Treatment, AWWA, Page 267-271, Mudball concentration.

MATERIALS NEEDED

1. Metal tube 3" in width and 6" in length.
2. 10 mesh sieve.
3. Two 8-quart buckets (one container large enough to submerge the mesh sieve).
4. Graduated cylinders: 100 mL, 250 mL, 500 mL.



DIRECTIONS

1. Drain filter until water level is 12" below the top of the media.
2. Using the metal sampler, collect five samples at random from the surface of the filter. This will equal 1/4 cu. ft.
3. Place all samples in a bucket.
4. Place a small portion of the sand on the 10 mesh sieve.
5. Wash the sand from the sieve by submerging the sieve in water and raising and lowering the sieve 1/2" until the sand has separated from the mudballs.

6. Move the mudballs to one side of the sieve by tilting the sieve 15-20 degrees and oscillating the sieve slightly.
7. Keep adding sand and washing.
8. If the volume of mudballs is high, you may need to occasionally remove the mudballs.
9. Select a graduated cylinder which will hold the mudball in 1/4 to 1/2 of its volume.
10. Fill the graduated cylinder 1/2 full of water. Record the level in mL.
11. Transfer the mudballs to the cylinder. Record the new volume.
12. Calculate % mudballs, evaluate filter condition and

$$\% \text{ Mudballs} = \frac{\text{vol of mudballs, mL}}{\text{total vol of sample, mL}} \text{X } 100$$

submit written report.

CALCULATIONS

1. $1/4 \text{ ft}^3 = 7068.6 \text{ mL}$
2. Vol. of grad. cylinder, mL - vol. of grad. cylinder with mudballs, mL = vol. of mudballs, mL
3.

Percent Volume of Mudballs	Condition of Filter
0.0 - 0.1	Excellent
0.1 - 0.2	Very good
0.2 - 0.5	Good
0.5 - 1.0	Fair
1.0 - 2.5	Fairly bad
2.5 - 5.0	Bad
Over 5.0	Very Bad

ALUM PROBLEMS

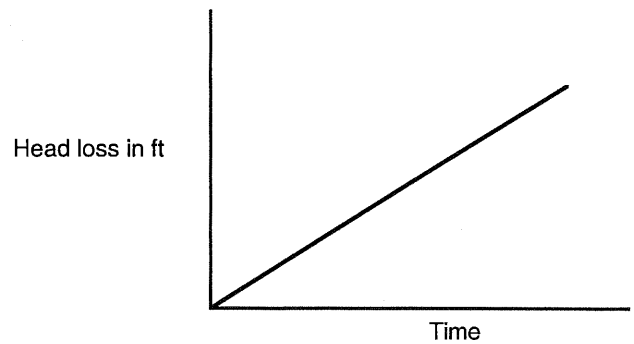
The following information was condensed from the April 1988 issue of the AWWA Journal - "Comparing Aluminum and Iron Coagulants for In-line Filtration of Cold Water."

Alum is most likely to fail when:

- the raw water turbidity is low,
- there is low water temperature,
- the coagulant is being over dosed.

Temperature

As water temperature drops, the floc formed by alum or ferric compounds decrease in size. An increase in alum dosage further reduces the size of the floc. However, an increase in ferric has no further impact on particle size.



The article indicated that a plot of head loss vs. time for each filter was a useful tool in determining if the full bed of the filter was being utilized. (The more of the filter bed that can be utilized the longer the filter run and the higher the quality of effluent.) A straight line is the most desirable.

Alum will give longer filter runs (14 hrs vs. 10) than ferric. However, the final effluent turbidity can be expected to be higher (0.4 for alum vs. 0.2 for ferric).

ALUMINUM CARRY THROUGH

The following material was condensed from an article in the April, 1988 AWWA Journal titled "Survey of Residual Aluminum in Filter Water".

Problems associated with aluminum carry through

- Hydrous Aluminum precipitates in the distribution system causing:
- Increased turbidity and customer complaints.
- Interference with disinfection - enmeshes and protects microorganisms.
- Reduces the carrying capacity of pipelines.

- High intake of Aluminum has been speculated as a causative agent in neurological diseases, such as Alzheimer Disease and Presenile Dementia.
- Dialysis patients exposed to elevated Aluminum may exhibit dialysis encephalography or bone mineralization disorders such as dialysis osteodystrophy.

Drinking Water Regulations

- Average intake of US adult is 20 mg/d.
- Recommended level of 50 µg/L.
- One of 83 contaminants to be regulated in 1989.
- One of EPA's 7 allowable substitutions.

Survey Results

- Of 91 utilities surveyed only 30% could meet the 50 µg/L MCL.

CONTROL OF AL^{+++}

- Feed at optimum pH.
- Check level of Aluminum in lime - some lime is high in Aluminum because the Aluminum is tied to silica in the lime. The silica is insoluble and thus passes through the plant taking with it the Aluminum.

Major Contributing factors to high Aluminum in finish water

- High raw water Aluminum.
- High treated water turbidity.
- Lime.
- Testing procedure - use of an atomic absorption device for testing because of acid digestion of some samples.

Best control - Keep the final turbidity less than 0.1 ntu.