

4.2 FILTRATION

Acceptable filters shall include, upon the discretion of the reviewing authority, the following types:

- a. rapid rate gravity filters,
- b. rapid rate pressure filters,
- c. diatomaceous earth filtration,
- d. slow sand filtration,
- e. direct filtration.

The application of any one type must be supported by water quality data representing a reasonable period of time to characterize the variations in water quality. Experimental treatment studies may be required to demonstrate the applicability of the method of filtration proposed.

4.2.1 Rapid rate gravity filters

4.2.1.1 Pretreatment

The use of rapid rate gravity filters shall require pretreatment.

4.2.1.2 Rate of filtration

The rate of filtration shall be determined through consideration of such factors as raw water quality, degree of pretreatment provided, filter media, water quality control parameters, competency of operating personnel, and other factors as required by the reviewing authority. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of the reviewing authority prior to the preparation of final plans and specifications.

4.2.1.3 Number

At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Where declining rate filtration is provided, the variable aspect of filtration rates, and the number of filters must be considered when determining the design capacity for the filters.

4.2.1.4 Structural details and hydraulics

The filter structure shall be designed to provide for

- a. vertical walls within the filter,
- b. no protrusion of the filter walls into the filter media,
- c. cover by superstructure as determined necessary under local climate,
- d. head room to permit normal inspection and operation,
- e. minimum depth of filter box of 8 1/2 feet,
- f. minimum water depth over the surface of the filter media of three feet,
- g. trapped effluent to prevent backflow of air to the bottom of the filters,
- h. prevention of floor drainage to the filter with a minimum 4-inch curb around the filters,
- i. prevention of flooding by providing overflow,
- j. maximum velocity of treated water in pipe and conduits to filters of two feet per second,
- k. cleanouts and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening,
- l. washwater drain capacity to carry maximum flow,
- m. walkways around filters, to be not less than 24 inches wide,
- n. safety handrails or walls around filter areas adjacent to normal walkways,
- o. construction to prevent cross connections and common walls between potable and non-potable water.

4.2.1.5 Washwater troughs

Washwater troughs should be constructed to have

- a. the bottom elevation above the maximum level of expanded media during washing,
- b. a two-inch freeboard at the maximum rate of wash,

- c. the top edge level and all at the same elevation,
- d. spacing so that each trough serves the same number of square feet of filter area,
- e. maximum horizontal travel of suspended particles to reach the trough not to exceed three feet.

4.2.1.6 Filter material

The media shall be clean silica sand or other natural or synthetic media approved by the reviewing authority, having the following characteristics:

- a. a total depth of not less than 24 inches and generally not more than 30 inches,
- b. an effective size range of the smallest material no greater than 0.45 mm to 0.55 mm,
- c. a uniformity coefficient of the smallest material not greater than 1.65,
- d. a minimum of 12 inches of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter.
- e. Types of filter media:
 - 1. Anthracite - Clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and shall have
 - a. effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone,
 - b. effective size of 0.8 mm - 1.2 mm with a uniformity coefficient not greater than 1.85 when used as a cap,
 - c. effective size for anthracite used as a single media on potable groundwater for iron and manganese removal only shall be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies).

2. Sand - sand shall have
 - a. effective size of 0.45 mm to 0.55 mm,
 - b. uniformity coefficient of not greater than 1.65.
3. Granular activated carbon (GAC) - Granular activated carbon media may be considered only after pilot or full scale testing and with prior approval of the reviewing authority. [REDACTED] shall include the following:
 - a. The media must meet the basic specifications for filter media as given in Section 4.2.1.6.a through d except that larger size media may be allowed by the reviewing authority where full scale tests have demonstrated that treatment goals can be met under all conditions.
 - b. There must be provisions for a free chlorine residual and adequate contact time in the water following the filters and prior to distribution (See 4.3.2.d and 4.3.3).
 - c. There must be means for periodic treatment of filter material for control of bacterial and other growth.
 - d. Provisions must be made for frequent replacement or regeneration if GAC is used for filtration.
4. Other media - Other media will be considered based on experimental data and operating experience.
5. Torpedo sand - A three-inch layer of torpedo sand should be used as a supporting media for filter sand, and should have
 - a. effective size of 0.8 mm to 2.0 mm, and
 - b. uniformity coefficient not greater than 1.7.
6. Gravel - Gravel, when used as the supporting media shall consist of hard, durable, rounded silica particles and shall not include flat or elongated particles. The coarsest gravel shall be 2 1/2 inches in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	Depth
2 1/2 to 1 1/2 inches	5 to 8 inches
1 1/2 to 3/4 inches	3 to 5 inches
3/4 to 1/2 inches	3 to 5 inches
1/2 to 3/16 inches	2 to 3 inches
3/16 to 3/32 inches	2 to 3 inches

Reduction of gravel depths may be considered upon justification to the reviewing authority when proprietary filter bottoms are specified.

4.2.1.7 Filter bottoms and strainer systems

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese may clog them or with waters softened by lime. The design of manifold-type collection systems shall:

- a. minimize loss of head in the manifold and laterals,
- b. assure even distribution of washwater and even rate of filtration over the entire area of the filter,
- c. provide the ratio of the area of the final openings of the strainer systems to the area of the filter at about 0.003,
- d. provide the total cross-sectional area of the laterals at about twice the total area of the final openings,
- e. provide the cross-sectional area of the manifold at 1 1/2 to 2 times the total area of the laterals.

4.2.1.8 Surface wash or subsurface wash

Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus. All devices shall be designed with

- a. provision for water pressures of at least 45 psi,
- b. a properly installed vacuum breaker or other approved device to prevent back siphonage if connected to the treated water system,
- c. rate of flow of 2.0 gallons per minute per square foot of filter area with fixed nozzles or 0.5 gallons per minute per square foot with revolving arms,

- d. air wash can be considered based on experimental data and operating experiences.

4.2.1.9 Air scouring

Air scouring can be considered in place of surface wash

- a. air flow for air scouring the filter must be 3-5 standard cubic feet per minute square foot of filter area when the air is introduced in the underdrain; a lower air rate must be used when the air scour distribution system is placed above the underdrains,
- b. a method for avoiding excessive loss of the filter media during backwashing must be provided,
- c. air scouring must be followed by a fluidization wash sufficient to re-stratify the media,
- d. air must be free from contamination,
- e. air scour distribution systems should be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles shall be designed to prevent media from clogging the nozzles or entering the air distribution system.
- f. piping for the air distribution system shall not be flexible hose which will collapse when not under air pressure and shall not be a relatively soft material which may erode at the orifice opening with the passage of air at high velocity.
- g. air delivery piping shall not pass down through the filter media nor shall there be any arrangement in the filter design which would allow short circuiting between the applied unfiltered water and the filtered water,
- h. consideration should be given to maintenance and replacement of air delivery piping,
- i. the backwash delivery system must be capable of 15 gallons per minute per square foot of filter surface area; however, when air scour is provided the backwash rate must be variable and should not exceed 8 gallons per minute per square foot unless operating experience shows that a higher rate is necessary to remove scoured particles from filter surfaces.

- j. the filter underdrains shall be designed to accommodate air scour piping when the piping is installed in the underdrain, and
- k. the provisions of Section 4.2.1.11 shall be followed.

4.2.1.10 Appurtenances

- a. The following shall be provided for every filter:
 - 1. influent and effluent sampling taps,
 - 2. an indicating loss of head gauge,
 - 3. an indicating rate-of flow meter. A modified rate controller which limits the rate of filtration to a maximum rate may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the reviewing authority.
- b. It is recommended the following be provided for every filter:
 - 1. a continuous or rotating cycle turbidity recording device for surface water treatment plants,
 - 2. wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing,
 - 3. a 1 to 1 1/2 inch pressure hose and storage rack at the operating floor for washing filter walls,
 - 4. provisions for filtering to waste with appropriate measures for backflow prevention (see Section 4.11).

4.2.1.11 Backwash

Provisions shall be made for washing filters as follows:

- a. a minimum rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media. A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filters,

- b. filtered water provided at the required rate by washwater tanks, a washwater pump, from the high service main, or a combination of these,
- c. washwater pumps in duplicate unless an alternate means of obtaining washwater is available,
- d. not less than 15 minutes wash of one filter at the design rate of wash,
- e. a washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide,
- f. a rate-of-flow indicator, preferably with a totalizer, on the main washwater line, located so that it can be easily read by the operator during the washing process,
- g. design to prevent rapid changes in backwash water flow.

4.2.1.12 Miscellaneous

Roof drains shall not discharge into the filters or basins and conduits preceding the filters.

4.2.2 Rapid rate pressure filters

The normal use of these filters is for iron and manganese removal. Pressure filters shall not be used in the filtration of surface or other polluted waters or following lime-soda softening.

4.2.2.1 General

Minimum criteria relative to rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

4.2.2.2 Rate of filtration

The rate shall not exceed three gallons per minute per square foot of filter area except where inplant testing as approved by the reviewing authority has demonstrated satisfactory results at higher rates.

4.2.2.3 Details of design

The filters shall be designed to provide for

- a. loss of head gauges on the inlet and outlet pipes of each filter,