

Recommended Standards For Water Works



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ILLINOIS IOWA MINNESOTA NEW YORK PENNSYLVANIA
INDIANA MICHIGAN MISSOURI OHIO WISCONSIN ONTARIO

4.0 GENERAL

The design of treatment processes and devices shall depend on evaluation of the nature and quality of the particular water to be treated, the desired quality of the finished water and the mode of operation planned.

4.1 CLARIFICATION

Plants designed for processing surface water shall

- a. provide a minimum of two units each for rapid mix, flocculation and sedimentation,
- b. permit operation of the units either in series or parallel where softening is performed and should permit series or parallel operation where plain clarification is performed,
- c. be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time,
- d. provide multiple-stage treatment facilities when required by the reviewing authority,
- e. be started manually following shutdown,
- f. minimize hydraulic head losses between units to allow future changes in processes without the need for repumping.

4.1.1 Presedimentation

Waters containing high turbidity may require pretreatment, usually sedimentation either with or without the addition of coagulation chemicals.

- a. Basin design - Presedimentation basins should have hopper bottoms or be equipped with continuous mechanical sludge removal apparatus, and provide arrangements for dewatering.
- b. Inlet - Incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.
- c. Bypass - Provisions for bypassing presedimentation basins shall be included.
- d. Detention time - Three hours detention is the minimum period recommended; greater detention may be required.

4.1.2 Rapid mix

Rapid mix shall mean the rapid dispersion of chemicals throughout the water to be treated, usually by violent agitation. The engineer shall submit the design basis for the velocity gradient (G value) selected, considering the chemicals to be added and water temperature, color and other related water quality parameters.

- a. Equipment - Basins should be equipped with mechanical mixing devices.
- b. Mixing - The detention period should be not more than thirty seconds.
- c. Location - The rapid mix and flocculation basin shall be as close together as possible.

4.1.3 Flocculation

Flocculation shall mean the agitation of water at low velocities for long periods of time.

- a. Basin Design - Inlet and outlet design shall prevent short-circuiting and destruction of floc. A drain and/or pumps shall be provided to handle dewatering and sludge removal.
- b. Detention - The flow-through velocity shall be not less than 0.5 nor greater than 1.5 feet per minute with a detention time for floc formation of at least 30 minutes.
- c. Equipment - Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second.
- d. Piping - Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be not less than 0.5 nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.
- e. Other designs - Baffling may be used to provide for flocculation in small plants only after consultation with the reviewing authority. The design should be such that the velocities and flows noted above will be maintained.
- f. Superstructure - A superstructure over the flocculation basins may be required.

4.1.4 Sedimentation

Sedimentation shall follow flocculation. The detention time for

effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units:

- a. Detention time - Shall provide a minimum of four hours of settling time. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. Reduced sedimentation time may also be approved when equivalent effective settling is demonstrated.
- b. Inlet devices - Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet end and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin.
- c. Outlet devices - Outlet devices shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow.
- d. Overflow rate - The rate of flow over the outlet weir shall not exceed 20,000 gallons per day per foot of weir length. Where submerged orifices are used as an alternate for overflow weirs, they should be not lower than three feet below the flow line with flow rates equivalent to weir loadings.
- e. Velocity - The velocity through settling basins shall not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.
- f. Overflow - An overflow weir (or pipe) should be installed which will establish the maximum water level desired on top of the filters. It shall discharge by gravity with a free fall at a location where the discharge will be noted.
- g. Superstructure - A superstructure over the sedimentation basins may be required. If there is no mechanical equipment in the basins and if provisions are included for adequate monitoring under all expected weather conditions, a cover may be provided in lieu of a superstructure.
- h. Sludge collection - Mechanical sludge collection equipment should be provided.
- i. Drainage - Basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than one foot in twelve feet where mechanical sludge collection equipment is not required.

- j. Flushing lines - Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to the reviewing authority.
- k. Safety - Permanent ladders or handholds should be provided on the inside walls of basins above the water level. Guard rails should be included.
- l. Sludge removal - Sludge removal design shall provide that
 - 1. sludge pipes shall be not less than three inches in diameter and so arranged as to facilitate cleaning,
 - 2. entrance to sludge withdrawal piping shall prevent clogging,
 - 3. valves shall be located outside the tank for accessibility,
 - 4. the operator may observe and sample sludge being withdrawn from the unit.
- m. Sludge disposal - Facilities are required by the reviewing authority for disposal of sludge. (see Section 4.11).

4.1.5 Solids contact unit

Units are generally acceptable for combined softening and clarification where water characteristics, especially temperature, do not fluctuate rapidly, flow rates are uniform and operation is continuous. Before such units are considered as clarifiers without softening, specific approval of the reviewing authority shall be obtained. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flow which are less than the design rate and for changes in water characteristics. A minimum of two units are required for surface water treatment.

4.1.5.1 Installation of equipment

Supervision by a representative of the manufacturer shall be provided with regard to all mechanical equipment at the time of

- a. installation, and
- b. initial operation.

4.1.5.2 Operating equipment

The following shall be provided for plant operation:

- a. a complete outfit of tools and accessories,

- b. necessary laboratory equipment,
- c. adequate piping with suitable sampling taps so located as to permit the collection of samples of water from critical portions of the units.

4.1.5.3 Chemical feed

Chemicals shall be applied at such points and by such means as to insure satisfactory mixing of the chemicals with the water.

4.1.5.4 Mixing

A rapid mix device or chamber ahead of solids contact units may be required by the reviewing authority to assure proper mixing of the chemicals applied. Mixing devices employed shall be so constructed as to

- a. provide good mixing of the raw water with previously formed sludge particles, and
- b. prevent deposition of solids in the mixing zone.

4.1.5.5 Flocculation

Flocculation equipment

- a. shall be adjustable (speed and/or pitch),
- b. must provide for coagulation in a separate chamber or baffled zone within the unit,
- c. should provide the flocculation and mixing period to be not less than 30 minutes.

4.1.5.6 Sludge concentrators

- a. The equipment should provide either internal or external concentrators in order to obtain a concentrated sludge with a minimum of waste water.
- b. Large basins should have at least two sumps for collecting sludge with one sump located in the central flocculation zone.

4.1.5.7 Sludge removal

Sludge removal design shall provide that

- a. sludge pipes shall be not less than three inches in diameter and so arranged as to facilitate cleaning,

- b. entrance to sludge withdrawal piping shall prevent clogging,
- c. valves shall be located outside the tank for accessibility, and
- d. the operator may observe and sample sludge being withdrawn from the unit.

4.1.5.8 Cross-connections

- a. Blow-off outlets and drains must terminate and discharge at places satisfactory to the reviewing authority.
- b. Cross-connection control must be included for the potable water lines used to backflush sludge lines.

4.1.5.9 Detention period

The detention time shall be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be

- a. two to four hours for suspended solids contact clarifiers and softeners treating surface water, and
- b. one to two hours for the suspended solids contact softeners treating only groundwater.

The reviewing authority may alter detention time requirements.

4.1.5.10 Suspended slurry concentrate

Softening units should be designed so that continuous slurry concentrates of one per cent or more, by weight, can be satisfactorily maintained.

4.1.5.11 Water losses

- a. Units shall be provided with suitable controls for sludge withdrawal.
- b. Total water losses should not exceed
 - 1. five per cent for clarifiers,
 - 2. three per cent for softening units.
- c. Solids concentration of sludge bled to waste should be
 - 1. three per cent by weight for clarifiers,

2. five per cent by weight for softeners.

4.1.5.12 Weirs or orifices

The units should be equipped with either overflow weirs or orifices constructed so that water at the surface of the unit does not travel over 10 feet horizontally to the collection trough.

- a. Weirs shall be adjustable, and at least equivalent in length to the perimeter of the tank.
- b. Weir loading shall not exceed
 1. 10 gallons per minute per foot of weir length for units used for clarifiers,
 2. 20 gallons per minute per foot of weir length for units used for softeners.
- c. Where orifices are used the loading rates per foot of launder rates should be equivalent to weir loadings. Either shall produce uniform rising rates over the entire area of the tank.

4.1.5.13 Upflow rates

Unless supporting data is submitted to the reviewing authority to justify rates exceeding the following, rates shall not exceed

- a. 1.0 gallon per minute per square foot of area at the sludge separation line for units used for clarifiers,
- b. 1.75 gallons per minute per square foot of area at the slurry separation line, for units used for softeners.

4.1.6 Tube or plate settlers

Proposals for settler unit clarification must include pilot plant and/or full scale demonstration satisfactory to the reviewing authority prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped tubes or plates which are installed in multiple layers and at an angle to the flow may be used for sedimentation, following flocculation.

4.1.6.1 General Criteria

- a. Inlet and outlet considerations -- Design to maintain velocities suitable for settling in the basin and to minimize short-circuiting.

- b. Drainage -- Drain piping from the settler units must be sized to facilitate a quick flush of the settler units and to prevent flooding other portions of the plant.
- c. Protection from freezing -- Although most units will be located within a plant, outdoor installations must provide sufficient freeboard above the top of settlers to prevent freezing in the units. A cover or enclosure is strongly recommended.
- d. Application rate -- A maximum rate of 2 gal/ft²/min of cross-sectional area (based on 24-inch long 60° tubes or 39.5-inch long 7 1/2° tubes), unless higher rates are successfully shown through pilot plant or in-plant demonstration studies.
- e. Flushing lines -- Flushing lines shall be provided to facilitate maintenance and must be properly protected against backflow or back siphonage.