

Alaska Department of Environmental Conservation
Operator Training and Certification Program

Water System Classification Information

Updated November 2016

System Classification Information

Small Untreated and Small Treated Water Systems

- Community or non-transient non-community water system that
 - Has < 100 service connections, serves < 500 people per day, and
 - Adds no chemicals: **Small Untreated Water System**
 - Adds one chemical: **Small Treated Water System**
 - Has < 15 service connections, serves ≥ 500 people per day, and
 - Adds no chemicals: **Small Untreated Water System**
 - Adds one chemical: **Small Treated Water System**
- Transient non-community water system that uses a surface water source or a groundwater under the direct influence of surface water source and adds one chemical: **Small Treated Water System**

Water Distribution and Water Treatment Systems

- Community or non-transient non-community water system that
 - Has ≥ 100 service connections;
 - Has ≥ 15 service connections and serves ≥ 500 people;
 - Has < 100 service connections, serves < 500 people, and uses complex water treatment; or
 - Has < 15 service connections, serves ≥ 500 people, and uses complex water treatment.
- Transient non-community water system that
 - Uses a surface water or groundwater under the influence of surface water source and uses complex water treatment; or
 - Uses a groundwater source, serves ≥ 500 people, and uses complex water treatment.
- Complex water treatment is a process that uses
 - Coagulation;
 - Chemically aided filtration;
 - Membrane filtration;
 - Ultraviolet light to meet surface water treatment inactivation requirement;
 - The addition of more than one chemical; or
 - A combination of water treatment processes that may require a high level of operator skill

System Classification Information

Water Distribution Systems:

- Class 1: 15 to 500 service connections
- Class 2: 501 to 5,000 service connections
- Class 3: 5,001 to 15,000 service connections
- Class 4: More than 15,000 service connections
- *Systems where water is circulated or heated to prevent freezing in the water distribution system will be classified one class higher than the class determined above*
- *Systems with five or more pressure zones will be classified at one class higher than the class determined above*
- *Systems with five or more pressure zones and where water is circulated or heated to prevent freezing in the water distribution system will be classified at one class higher than the class determined above*

System Classification Information

Water Treatment Systems:

- Class 1: 1 – 30 points
- Class 2: 31 – 55 points
- Class 3: 56 – 75 points
- Class 4: 76 points and greater

Point Rating System:

Size

Peak day design capacity, gallons per day:

- Less than 10,000: 1
- 10,000 – 50,000: 2
- 50,001 – 100,000: 4
- 100,001 – 500,000: 9
- 500,001 – 1,000,000: 12
- 1,000,001 – 5,000,000: 16
- 5,000,001 – 10,000,000: 20
- 10,000,001 – 50,000,000: 25
- Greater than 50,000,000: 30

Water Supply Source

- Groundwater: 2
- Groundwater under the direct influence of surface water: 4
- Surface water: 6
- Surface water maintaining filtration avoidance criteria: 8
- Seawater: 10
- Purchased treated water: 0
- Raw water storage tank: 3

Pretreatment

- Presedimentation basin: 4
- Hydrocyclone or similar sand separator device: 2
- Microscreen: 3
- Roughing filter:
 - Cartridge filter: 2
 - Non-backwashable strainer or filter: 2

- Gravel or rock filter: 4
 - Backwashable granular media filter: 8
- Add-heat system to heat raw water: 2

Adjustment and Corrosion Control

- pH adjustment: 3
- Corrosion inhibitor: 3
- Limestone or calcite contactor: 2
- Sequestration: 3

Treatments

- Aeration:
 - In-line venturi-type: 1
 - Mechanical or diffused: 3
- Degasification: 3
- Ion exchange: 4
- Non-regenerated sorption processes, including activated alumina, modified activated alumina, and iron based sorbents: 3
- On-site regeneration of sorption process media: 10
- Activated carbon, if not included as a bed layer in another filter:
 - Activated carbon cartridge or bag filter: 2
 - Powdered activated carbon treatment: 4
 - Granular activated carbon contactors: 4
 - On-site regeneration of activated carbon: 16
- Chemical oxidation:
 - Hypochlorite solution: 3
 - Gas chlorine: 12
 - Potassium permanganate: 4
 - Hydrogen peroxide: 5
- Ozonation without pure oxygen: 3
- Ozonation with pure liquefied oxygen: 4
- Ozonation with on-site generation of pure oxygen: 5
- Coagulation:
 - Primary coagulant: 5
 - Coagulant aid, flocculent, or filter aid: 3 points for each chemical added, up to a maximum of 12 points
- Rapid mix units:
 - Mechanical mixers: 5
 - Injection mixers: 3
 - In-line blender mixers: 2

- In-line static mixers: 0
- Flocculation tanks:
 - Hydraulic flocculator: 4
 - Mechanical flocculator: 8
- Sedimentation or clarification:
 - Tube settlers: 2
 - Inclined-plate, Lamella-type or equivalent: 2
 - Horizontal flow conventional clarifier: 4
 - Batch sedimentation: 2
 - Adsorption clarifier: 6
 - Up-flow solids contact: 10
 - Dissolved air flotation: 16
 - Combined rapid mix-coagulation-flocculation-sedimentation unit: 20
- Filtration:
 - Cartridge or bag filter – single unit: 2
 - Cartridge or bag filters – staged, multiple units: 4
 - Slow sand: 4
 - Granular media: 8
 - Membrane filtration, including reverse osmosis, microfiltration, ultrafiltration, or nanofiltration: 8
 - Membrane filtration, integrated system: 12
 - Diatomaceous earth: 12
- Electrodialysis, electrodialysis reversal, distillation: 10
- Lime softening: 16
- Recarbonation: 8
- Fluoridation:
 - Sodium fluoride saturator: 2
 - Sodium silicofluoride: 3
 - Hydrofluorosilicic acid: 5
- Disinfection:
 - Liquid and powdered hypochlorites: 3
 - Additional points if hypochlorites are generated on-site: 2
 - Gas chlorine: 12
 - Chlorination using tablets: 1
 - Ammonia addition for chloramination:
 - using liquid ammonia solution: 3
 - using ammonia gas: 12
 - Chlorine dioxide: 8
 - Chlor-alkali on-site generation: 12

- Ozonation without pure oxygen: 3
 - Ozonation with pure liquefied oxygen: 4
 - Ozonation with on-site generation of pure oxygen: 5
 - Ultraviolet light: 2
 - Ultraviolet light, for the purposes of meeting required inactivation: 4
- Water storage tank, for the purpose of achieving contact time: 3
- Finished water storage tank, if the system serves fewer than 500 people or 100 service connections, and
 - the tank has a capacity of one million gallons or more: 3
 - the tank has a capacity 50,000 and 999,999 gallons: 2
 - the tank has a capacity of less than 50,000 gallons: 1
- Pressure tanks: 0
- On-site treatment of system sludge or backwash:
 - Discharge to sewer or other off-site treatment: 0
 - Discharge to on-site pond, septic tank, or lagoon: 2
 - Mechanical dewatering: 6
 - Filter backwash water or sludge supernatant recycling
 - groundwater source: 2
 - surface water source: 3

WT Facility Component Information

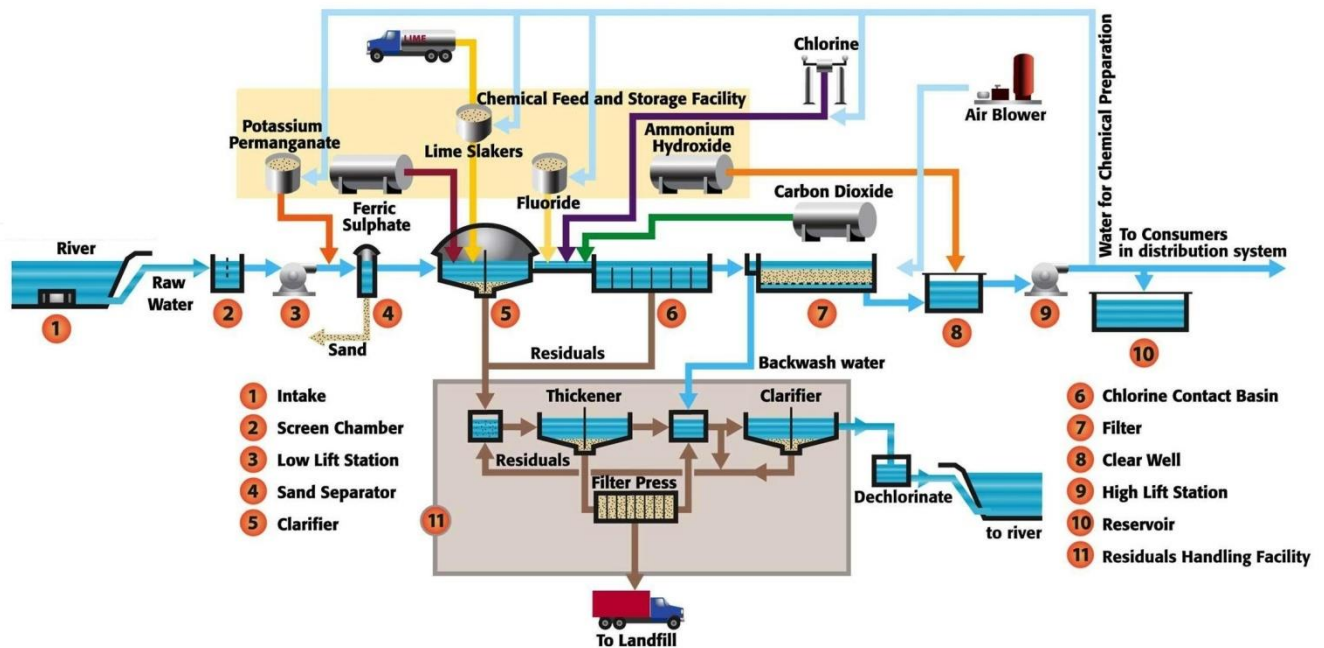


Figure 1 (Courtesy of Saskatoon, Canada 2012 Water Quality Report)

Pretreatment

- ◆ **Presedimentation Basin:** A basin used for sedimentation of source water with high turbidity prior to further treatment.

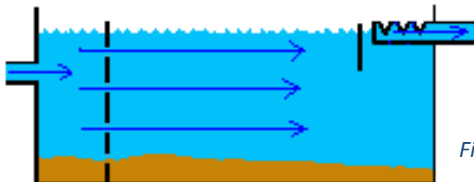


Figure 2 (Courtesy of Mountain Empire Community College Water/Wastewater Site)

- ◆ **Centrifugal sand-and-grit removal device (Hydrocyclone or cyclone degritter):** A device which uses centrifugal force to separate sand or other heavy materials from the incoming raw water.

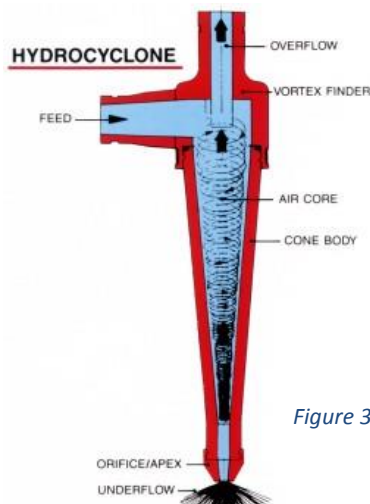


Figure 3 (Courtesy of Jiangxi Gandong Mining Equipment Machinery Manufacturer Factory)

- ◆ **Microscreen:** A pretreatment device used to remove fine material such as filamentous algae. Screening media are typically stainless steel or polyester, and media openings are typically 20 to 30 micrometers.



Figure 4 (Courtesy of Hydrotech)

- ◆ **Roughing Filter:** A filter for partial removal of turbidity prior to treatment.
Types:
 - Cartridge Filter
 - Non-backwashable strainer or filter
 - Gravel or rock filter
 - Backwashable granular media filter

Adjustment and Corrosion Control

- ◆ **pH Adjustment:** Addition of chemicals to minimize corrosion or scaling, maximize the effectiveness of disinfection, coagulation, or flocculation.
Examples of chemicals added:
 - Calcium bicarbonate
 - Hydrochloric acid
 - Phosphoric acid
 - Potassium hydroxide
 - Sodium hydroxide
 - Sulfuric acid
- ◆ **Corrosion Inhibitor:** Addition of chemicals to prevent/minimize corrosion.
Examples of chemicals added:
 - Calcium hydroxide (hydrated lime)
 - Calcium oxide (quicklime)
 - Sodium carbonate (soda ash)
 - Sodium hydroxide (caustic soda)
 - Zinc orthophosphate
- ◆ **Limestone or calcite contactor:** A treatment device consisting of a bed of limestone through which water is passed to dissolve calcium carbonate (CaCO_3). The addition of calcium carbonate to the water decreases corrosivity by increasing the pH, calcium concentration, and alkalinity of the water.

Limestone Contactor

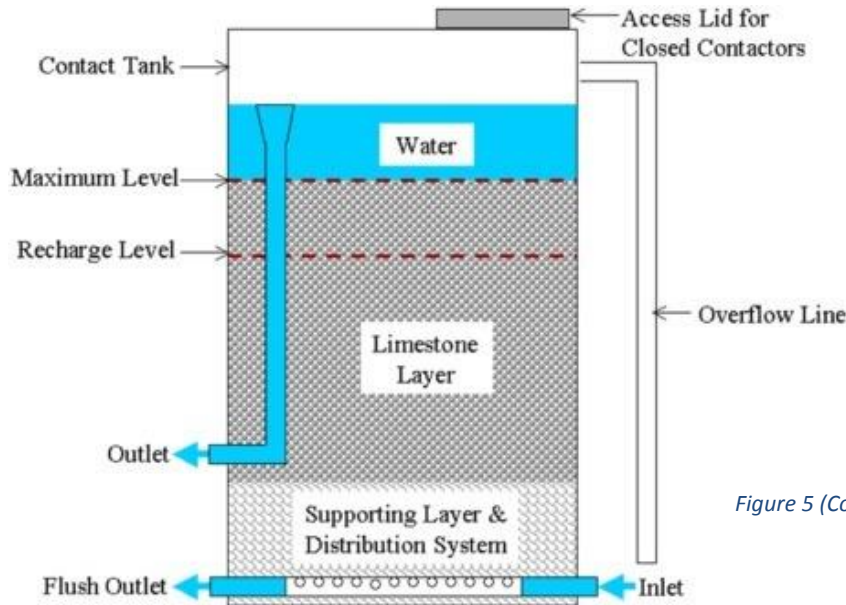


Figure 5 (Courtesy of Nikolay Voutchkov © 2011)

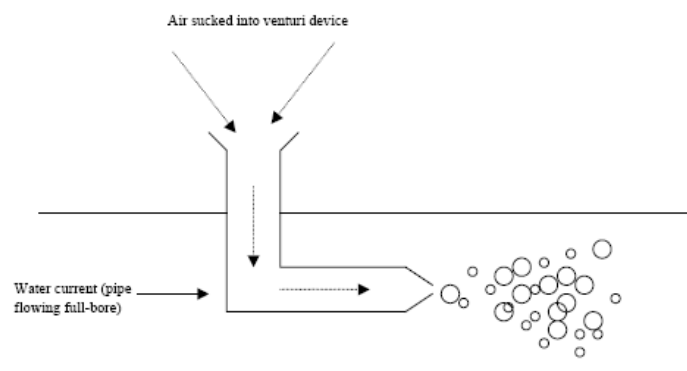
- **Sequestration:** A chemical reaction in which certain chemicals (sequestering or chelating agents) “tie up” other chemicals, particularly metal ions, so that the chemicals no longer react. Sequestering agents are used to prevent the formation of precipitates or other compounds.

Example of sequestering agents:

- Sodium hexaphosphate
- Tetrasodium pyrophosphate
- Ethylenediaminetetraacetic acid (EDTA)

Treatments

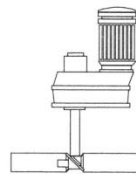
- **Aeration:** The process of bring water and air into close contact to remove or modify constituents in the water.
 - **In-line venturi type:** A small pipe, open to the atmosphere at one end, is submerged in a pipe flowing at full bore. The submerged end of the pipe faces downstream. As water flows down the pipe air is entrained through the end of the pipe open to the atmosphere.



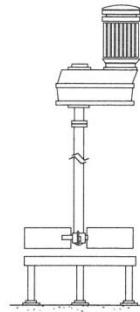
- **Mechanical:** Aeration of the water by mechanical means, usually some type of mechanical agitation.

Examples of mechanical aerators:

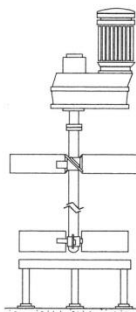
- Surface aerator
- Submerged aerator
- Combination mechanical aerator
- Draft-tube surface aerator



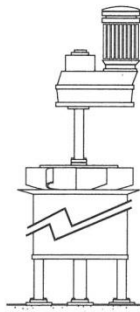
A. Surface aerator



B. Submerged aerator



C. Combination mechanical aerator



D. Draft-tube surface aerator

Figure 6 (Courtesy of Philadelphia Mixers Corporation)

- **Diffused:** Aeration achieved by the use of air compressor, piping, manifolds, and diffusers.

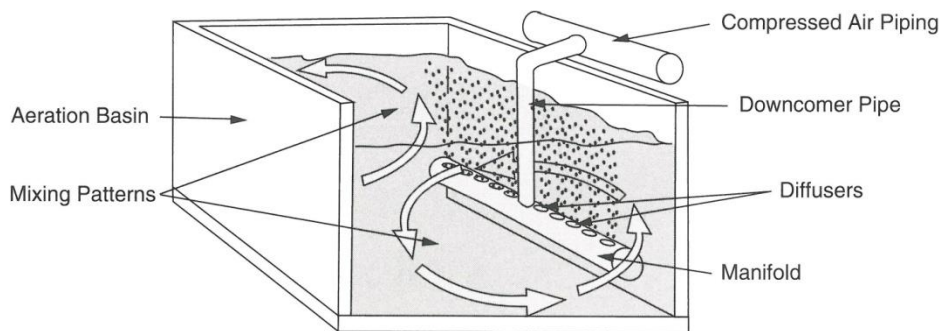


Figure 7 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- ◆ **Degasification:** The removal of dissolved gases from water to reduce their impact on water quality, filter operation (via air binding), pump cavitation, corrosion, or other parameters. Degasification is accomplished by mechanical methods (e.g., a degasifier or venturi), chemical methods, or a combination of both.

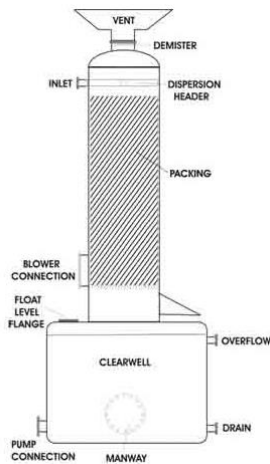


Figure 8 (Courtesy of Pure Aqua, Inc.)

- ◆ **Ion exchange:** A reversible chemical process in which ions from an insoluble permanent solid medium (the ion exchanger—usually a resin) are exchanged for ions in a solution or fluid mixture surrounding the insoluble medium. The superficial physical structure of the solid is not affected. The direction of the exchange depends on the selective attraction of the ion exchanger resin for the certain ions present and the concentrations of the ions in the solution. Both cation and anion exchange are used in water conditioning. Cation exchange is commonly used for water softening, i.e. removal of calcium and magnesium from water.

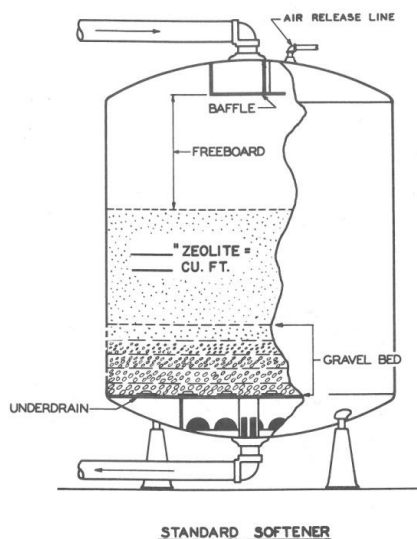


Figure 9 (Courtesy of Mountain Empire Community College Water/Wastewater Distance Learning)

- ◆ **Arsenic removal:** Arsenic is removed either by ion exchange or use of some type of adsorption media. Arsenic typically occurs in one of two inorganic forms: the pentavalent arsenate, As(V), and the trivalent arsenite, As(III). In the pH range of 4 to 10, As(V) species are negatively charged, and the predominant As(III) compound is neutral in charge. Removal efficiency for As(V) is much better than removal for As(III). Therefore, in most cases, reduced inorganic As(III) should be converted to As(V) to facilitate removal. Chlorine, permanganate, ozone, and manganese dioxide media are effective oxidizing agents for this process. Aeration (i.e. oxygen) is not an effective method for oxidizing As(III).

- **Sorption process:** Use of an adsorbent media to remove arsenic.

Examples of types of media used that cannot be regenerated or will not be regenerated on-site:

- Activated alumina: AA-400G, DD-2, CPN, ARM
- Modified activated alumina: AAFS-50
- Iron-based: G2, SMI III, GFH, Bayoxide E 33

Examples of types of media used that are regenerated on-site:

- Activated alumina: AA-400G, DD-2, CPN, ARM
- Modified activated alumina: AAFS-50

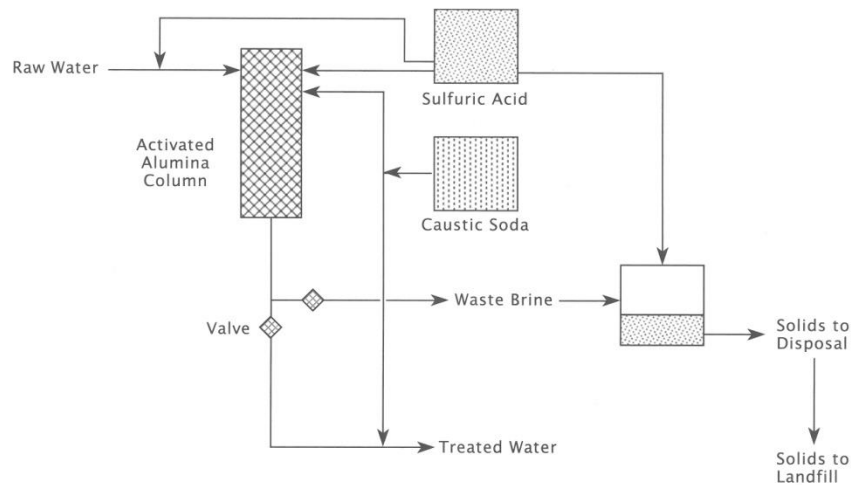


Fig. 15.4 Activated alumina arsenic removal treatment process

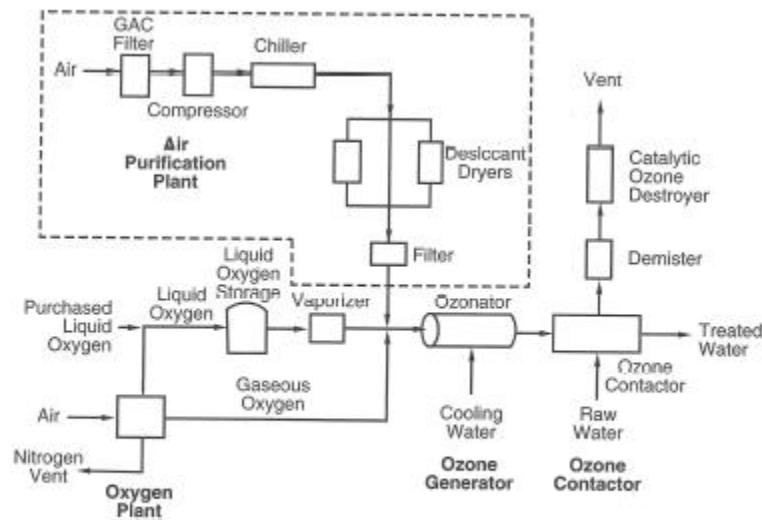
Figure 10 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

- **Activated carbon:** A form of particulate carbon (a crude form of graphite) with increased surface area to enhance adsorption of soluble contaminants.
 - *Activated carbon cartridge or bag filter:* A cartridge or bag filter containing activated carbon which is discarded after use.
 - *Powdered activated carbon (PAC) treatment:* Powdered activated carbon is added to the raw water as a chemical slurry and is removed along with chemical sludge after sedimentation.
 - *Granular activated carbon (GAC) filters:* Granular activated carbon is used as a medium in a conventional filter, i.e. not as a layer in a conventional multi-media filter
 - *On-site regeneration of activated carbon:* The process of restoring the adsorption capacity of GAC by thermal means. Used, or spent, activated carbon is removed from the process, dewatered, and combusted in furnaces in the absence of oxygen to remove adsorbed contaminants and restore the microporous structure (i.e., to increase surface area) for adsorption. Except for very large installations, it is not generally cost effective to regenerate GAC; therefore, the GAC is discarded and replaced with new material.
- **Chemical oxidation:** The process of using an oxidizing chemical to remove or change some contaminant in water by removing electrons.
 - *Hypochlorite solution/Gas chlorine:* Used to oxidize manganese, iron, hydrogen sulfide, taste and odor compounds, and various organic substances in the water.

- *Potassium Permanganate*: Used to oxidize iron, manganese, trihalomethane (THM) precursors (humic and fulvic acids), taste and odor compounds, and hydrogen sulfide.
- *Hydrogen Peroxide*: Used to oxidize THM precursors and taste and odor compounds.
- ◆ *Ozonation*: The process of applying ozone (O_3) to water for disinfection or odor control. Ozone must be generated on-site because it decomposes to oxygen (O_2) in a short time after generation. Ozone is produced when O_2 molecules are exposed to an energy source and converted to O_3 , which is an unstable gas. O_3 is a very strong oxidant and virucide.

Ozone Generator

Figure 11 (Courtesy of esemag.com)



Source: Water Quality and Treatment, 4th ed. (1990).

FIGURE 7-40 Flow diagram for air and oxygen purification for ozone production

Figure 12 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- ◆ *Coagulation*: The process of destabilizing charges on particles in water by adding chemicals (coagulants). Natural particles in water have negative charges that repel other material and thereby keep it in suspension. In coagulation, positively charged chemicals are added to neutralize or destabilize these charges and allow the particles to accumulate and be removed by physical processes such as sedimentation or filtration.
 - *Primary Coagulants*:
 - Aluminum sulfate (Alum)
 - Ferric chloride

- Ferric sulfate
 - Ferrous sulfate
 - Sodium silicate
 - Cationic Polymer
 - Anionic Polymer
 - Nonionic Polymer
- *Coagulant aid/Flocculant aid*: A chemical added during coagulation to improve the process by stimulating floc formation or by strengthening the floc so it holds together better.
 - Activated silica: Typically, sodium silicate which is then “activated” by adding an acid (hypochlorous acid) to reduce the alkalinity. Strengths the floc.
 - Weighting agents: Used to treat water high in color, low in turbidity, and low in mineral content. Examples are bentonite clay, powdered limestone, or powdered silica.
 - Polyelectrolytes (Polymers): When dissolved in water, it produces highly charged ions.
 - Cationic Polymers: When dissolved in water, they produce positively charged ions. They are widely used because suspended and colloidal solids commonly found in water are generally negatively charged.
 - Anionic Polymers: When dissolved in water, they produce negatively charged ions which are used to remove positively charge ions. Typically used with aluminum and iron coagulants.
 - Nonionic Polymer: When dissolved in water, they have a neutral charge.
 - *Filter Aid*: An agent (such as a polymer) that improves filtering effectiveness in some way, such as by enhancing the retention of particles or increasing the permeability of the filter to water flow. A filter aid is either added to the suspensions to be filtered or placed on the filter as a layer through which the liquid must pass. The polymer strengthens the bonds between the filtered particles and coats the media grains to improve adsorption.

Rapid Mix Units

Mixes chemicals with raw water containing fine particles that will not readily settle out or filter out of the water.

💧 *Mechanical mixer:*

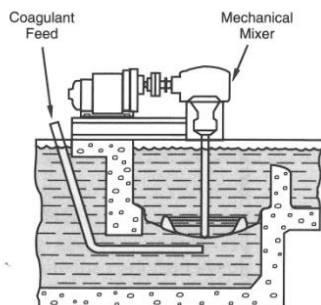


FIGURE 4-8 Mechanical mixing chamber—single-blade mixer

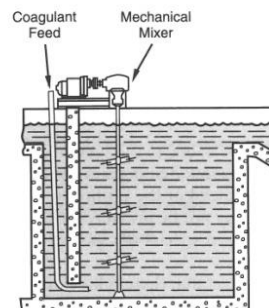


FIGURE 4-9 Mechanical mixing chamber—multiple-blade mixer

Figure 13 (Courtesy of AWWA WSO: *Water Treatment, 3rd Ed.*)

💧 **Injection mixer:**

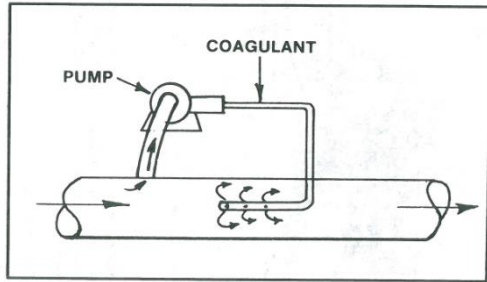


Figure 14 (Courtesy of CSU Water Treatment Plant Operation, Vo. I, Sixth Ed.)

Note: Simple chemical injection points are not considered injection mixers.

💧 **In-line blender mixer:**

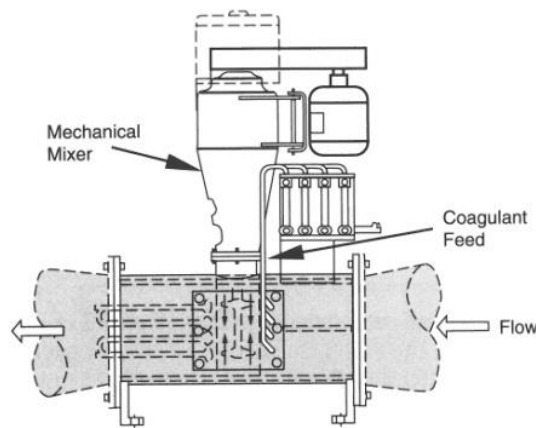
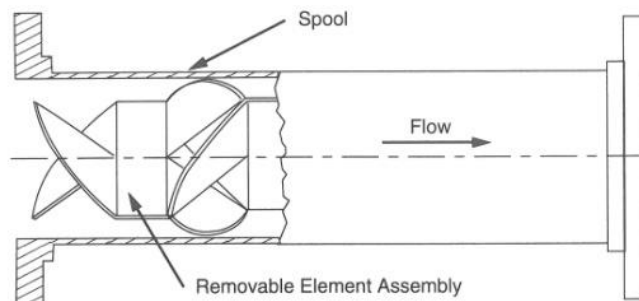


FIGURE 4-10 In-line mixer

Figure 15 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

💧 **In-line static mixer:**



Source: Water Quality and Treatment. 5th ed. (1999).

FIGURE 4-11 Section view of a static mixer

Figure 16 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

Flocculation Tanks

A flocculator is a device used to enhance the formation of floc in a liquid. Mixing energy can be provided by head loss (hydraulic) or mechanical means.

Hydraulic flocculator:

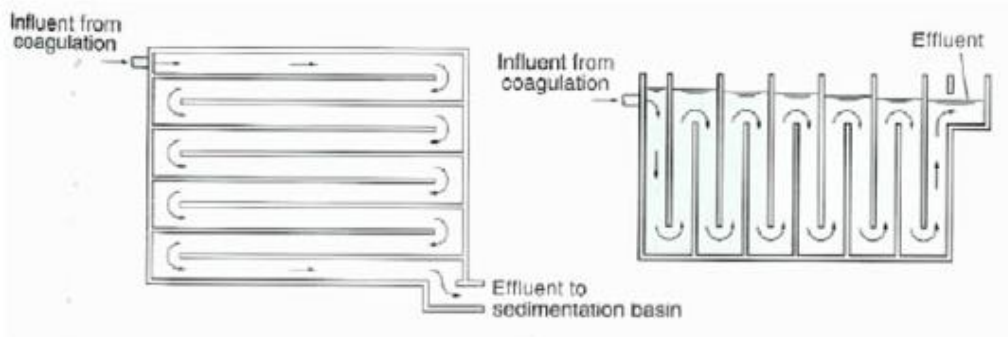


Figure 17 (Courtesy of Mountain Empire Community College Water/Wastewater Site)

Mechanical flocculator:

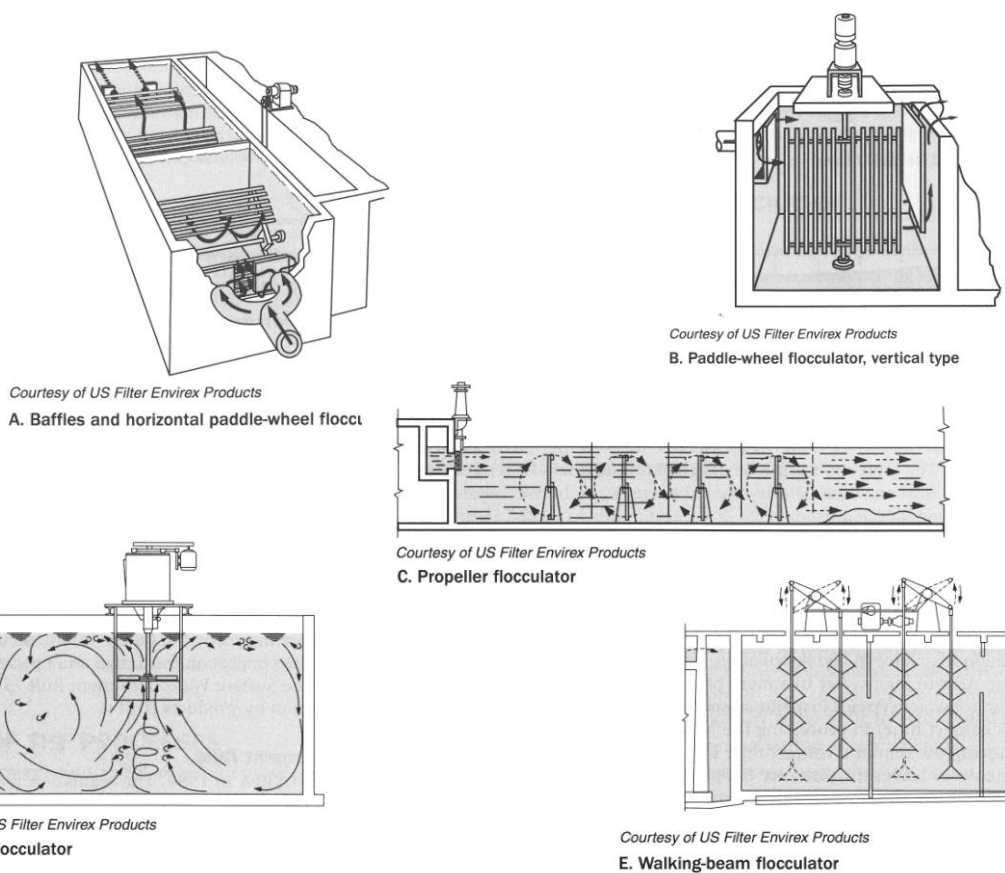
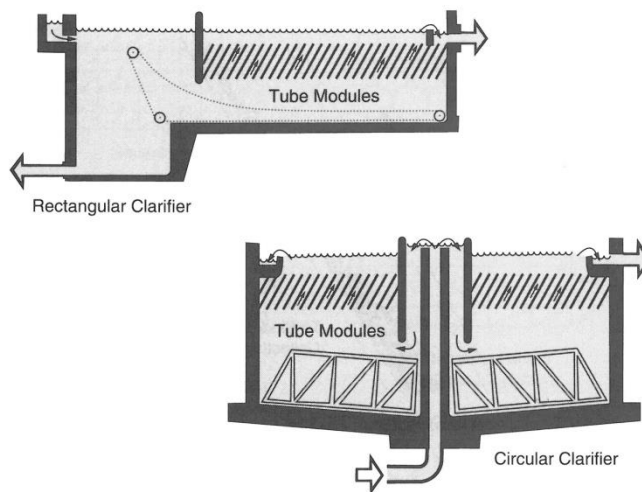


Figure 18 A, B, C, D, and E. (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

Sedimentation or Clarification

A water treatment process in which solid particles settle out of the water being treated in a large clarifier or sedimentation basin.

- Tube settlers:** A unit constructed of parallel tubes that are typically arranged in a honeycomb fashion and are approximately 2 inches in width oriented at a 45° to 60° angle from horizontal. Tube settlers are used to improve settling in a sedimentation basin. The units are placed at the end of the sedimentation basin (across the entire width) and flow travels upward through the tubes and exits at the top, prior to being discharged from the basin. The inclined tubes provide a much shorter distance for particles to settle prior to being captured, resulting in a low overflow rate, and they are often used to maintain particle removal at higher flow rates, thereby reducing the need to construct additional basins.

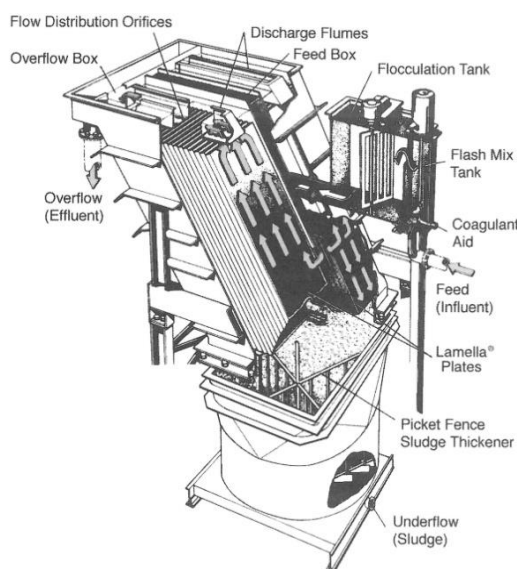


Courtesy of Wheelabrator Engineered Systems—Microfloc

FIGURE 5-10 Tube settlers installed in sedimentation basins

Figure 19 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- Inclined-plate separator:** A unit constructed of multiple parallel plates, approximately 2 inches apart and oriented at a 45° to 60° angle from the horizontal, to improve settling in a sedimentation basin. The units are placed at the end of a sedimentation basin (across the entire width), and flow travels upward through the plates and exits at the top prior to being discharged from the basin (a configuration called counterflow). Cocurrent and cross flow may also be used. The inclined plates provide a much shorter distance for particles to settle prior to being captured and are often used to maintain particle removal at higher flow rates, thereby reducing the need to construct additional basins.



Courtesy of Parkson Corporation

FIGURE 5-11 Lamella® plates

Figure 20 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- Horizontal flow conventional clarifier:** A large circular or rectangular tank or basin in which water is held for a period of time during which the heavier suspended solids settle to the bottom. The flow of the water is in a horizontal direction. In a rectangular basin, the flow can be from one end to the other. In a circular basin, the flow can be from the center out or from the periphery to the center.

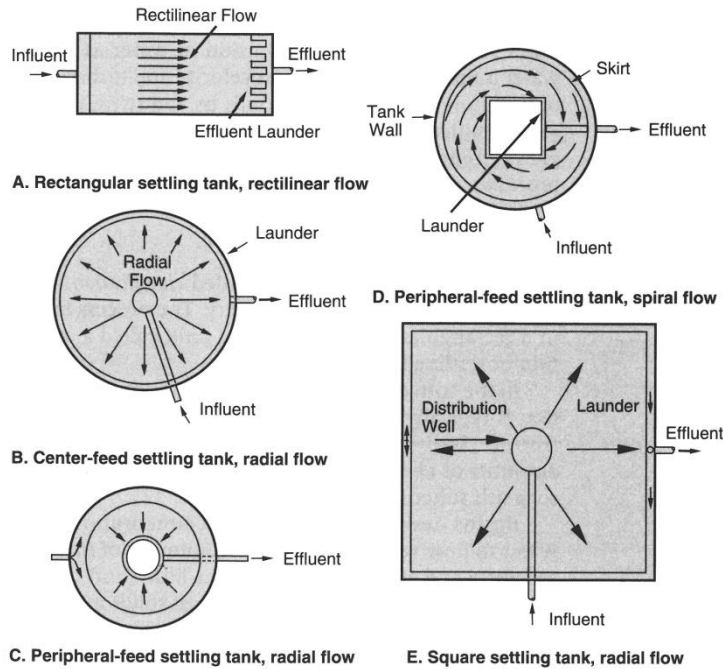
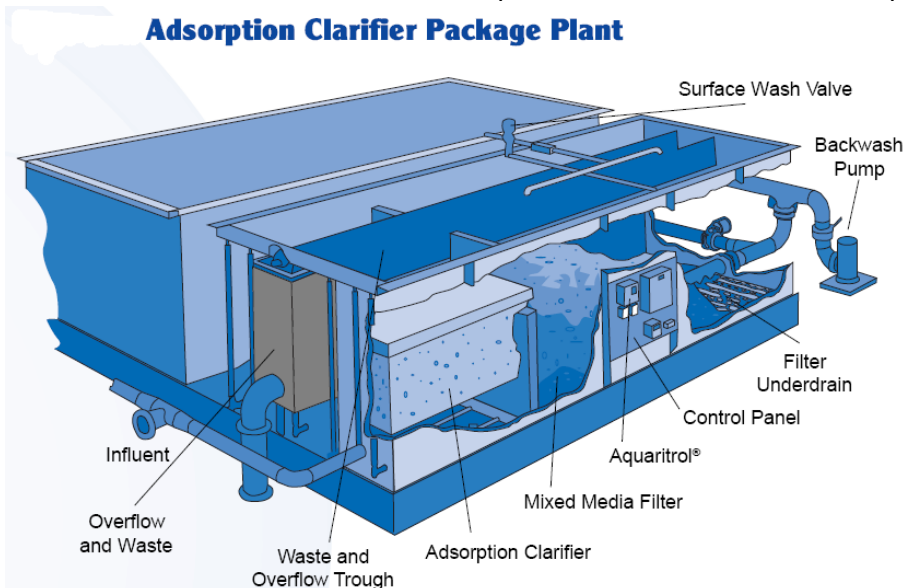


FIGURE 5-1 Overhead views of flow patterns in sedimentation basins

Figure 21 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- Adsorption clarifier:** In an adsorption clarifier, coagulant is added as water enters the bottom of the unit. Water travels through an upflow filter containing low density plastic bead media where flocculation and sedimentation takes place. The floc adheres to the plastic media; thereby, eliminating the need for sedimentation.

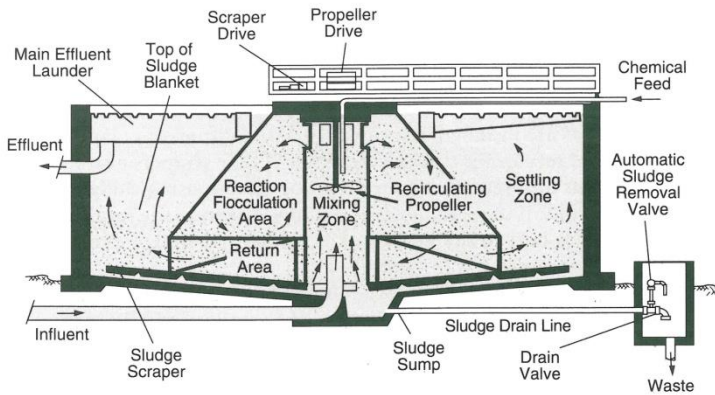


Source: U.S. Environmental Protection Agency, 1989

Figure 22 (Courtesy of U.S. Environmental Protection Agency; 1989)

◆ **Up-flow solids contact clarifier:** A unit process in which both flocculation and particle separation occur.

Coagulated water is passed upward through a solids blanket, allowing flocculation and particle separation to take place in a single step. The solids blanket is typically 6 to 10 feet below the water surface, and clarified water is collected in launder troughs along the top of the unit. Solids are continually withdrawn from the solids blanket to prevent undesired accumulation.



Courtesy of US Filter-General Filter Products

FIGURE 5-13 Sludge-blanket clarifier

Figure 23 (Courtesy of US Filter - General Filter Products)

◆ **Dissolved air flotation:** A process in which air is dissolved into water under high pressure and is subsequently released into the bottom of a treatment unit to float solids. Upon release, the lower pressure in the unit results in the formation of bubbles that collect particles as they rise to the surface. The floated particles are then skimmed for subsequent processing. This process is effective in removing low-density solids and algae.

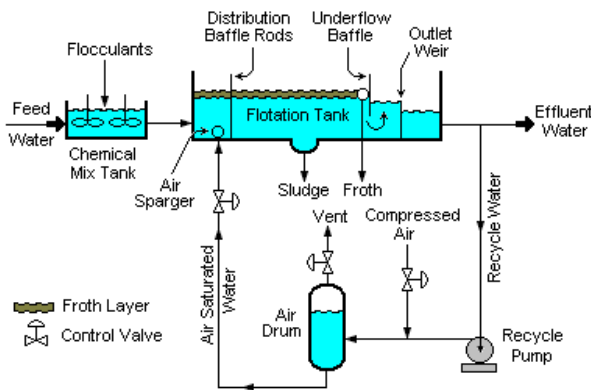


Figure 24 (Courtesy of Paper and Fibre Research Institute)

- ◆ **Combined rapid mix-coagulation-flocculation-sedimentation unit:** A clarifier unit that combines rapid mixing of the coagulant, coagulation, flocculation, and sedimentation all in one unit. An example is a ClariCone solids contact clarifier.

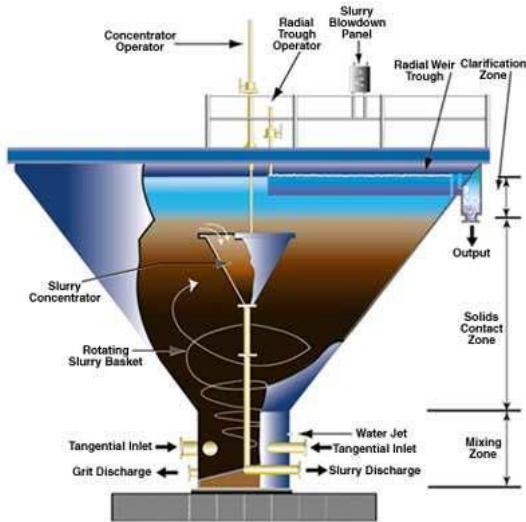


Figure 25 (Courtesy of CB&I)

Filtration

- ◆ **Cartridge filter:** A filtration device that has a pressure vessel containing one or more cartridges of a specified nominal (or sometimes absolute) pore size rating used to remove particles from a process stream.



Figure 26 (Courtesy of Waterco)

- ◆ **Bag filter:** A filtration device that uses filters in the shape of a bag in a polypropylene or stainless steel housing remove particles from a process stream. Bag filters are discarded after use.



Figure 27 (Courtesy of Eaton Corp.)

- Slow sand filter:** A filter for the purification of water in which water, without previous treatment, is passed downward through a filtering medium consisting of a layer of sand 24 to 40 inches thick. The filtrate is removed by an underdrainage system, and the filter is cleaned by scraping off the clogged sand and eventually replacing the sand. A slow sand filter is characterized by a slow rate of filtration, commonly 0.015 to 0.15 gallons per minute (gpm) per square foot of filter area. Its effectiveness depends on the biological mat, or schmutzdecke, that forms on the top of the filter.

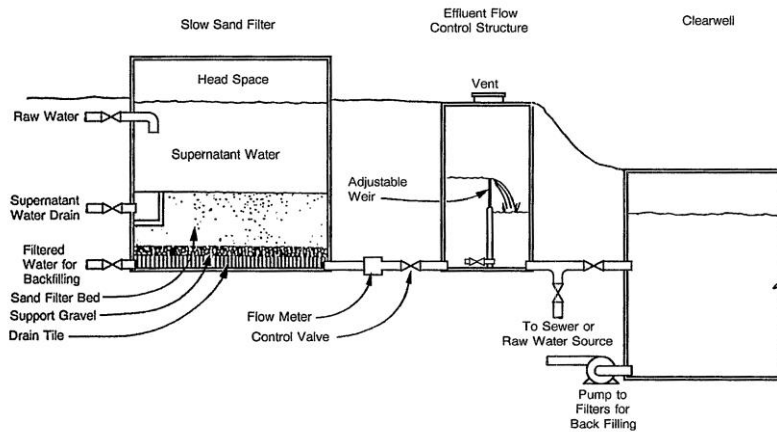


Figure 28 (Courtesy of Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities)

- Granular media filter:** A filter consisting of sand or other type of granular material, such as activated carbon or manganese greensand, usually used to remove iron and manganese precipitates. There is typically a backwash cycle associated with granular media filters. Manganese green sand filters used for the removal of iron and manganese are considered granular media filters under the point rating system. The air scour associated with backwash is not considered aeration under the point rating system.

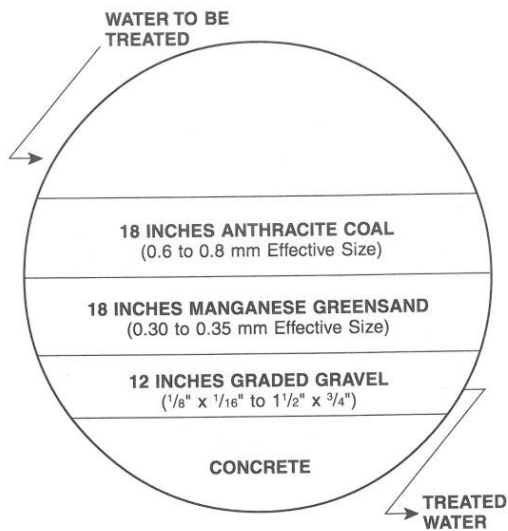


Fig. 12.4 Multi-media manganese greensand filter (horizontal)

Figure 29 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

💧 **Membrane filtration:** Filtration by use of a natural or synthetic semipermeable material.

SIZE, MICRONS	IONIC RANGE	MOLECULAR RANGE	MACRO RANGE	MICRO PARTICLE RANGE
	0.001	0.01	0.1	1.0
MEMBRANE PROCESSES	REVERSE OSMOSIS		MICROFILTRATION	
	NANOFILTRATION			
	ELECTRODIALYSIS	ULTRAFILTRATION		
RELATIVE SIZE OF VARIOUS MATERIALS IN WATER	AQUEOUS SALTS			
	METAL IONS			
		VIRUSES		BACTERIA
			HUMIC ACIDS	ALGAE
				CYSTS
			CLAYS	SILT
			ASBESTOS FIBERS	
			SUSPENDED SOLIDS	
		NOM		

Fig. 16.1 Size ranges of membrane processes and contaminant

(Adapted from AWWA, WATER QUALITY AND TREATMENT: A HANDBOOK OF COMMUNITY WATER SUPPLIES, 5th edition, McGraw-Hill, 1999)

Figure 30 (Courtesy of AWWA, Water Quality and Treatment: A Handbook of Community Water Supplies, 5th ed. McGraw Hill, 1999)

- Types from largest pore diameters to smallest.
 - Microfiltration (MF)
 - Ultrafiltration (UF)
 - Nanofiltration (NF)
 - Reverse Osmosis (RO)

Microfiltration

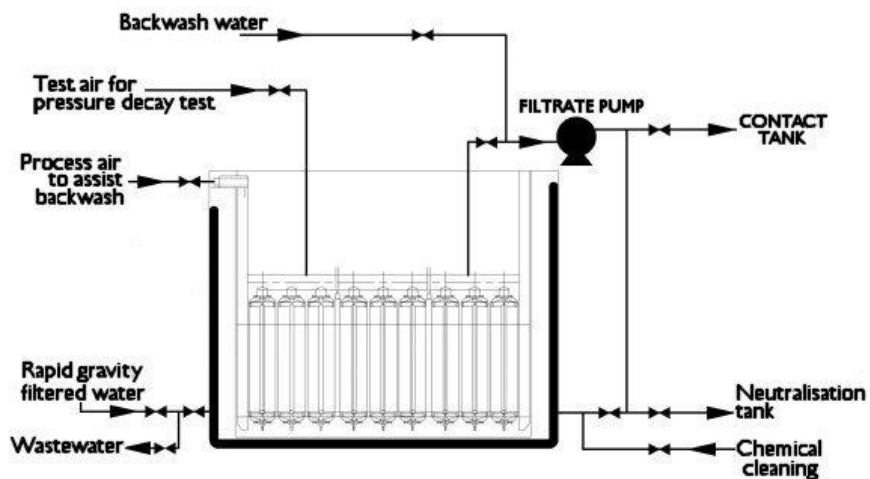


Figure 31 (Courtesy of Portsmouth Water)

Ultrafiltration



Figure 32 (Courtesy of Enviro Tech)

Nanofiltration



Figure 33 (Courtesy of sofi.usgs.gov)

Reverse Osmosis



Figure 34 (Courtesy of Hausers Water Systems)

- ◆ **Diatomaceous earth filtration:** A filtration method in which diatomaceous earth is used as the filtering medium. Initially, a $\frac{1}{8}$ to $\frac{3}{16}$ inch thick layer, or precoat, is applied to a septum or filter element. During operation, diatomaceous earth is fed continuously until a terminal head loss is reached, after which the filter influent is shut off and the diatomaceous earth layer falls off and is discharged. This type of filtration is best applied to source waters that have consistently low turbidity.

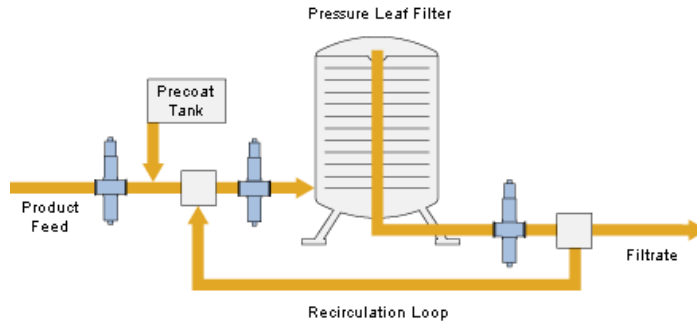


Figure 35 (Courtesy of Optek)

Electrodialysis (ED)

An electrochemical separation process in which ions are transferred through selective ion exchange membranes from one solution to another by means of a DC voltage.

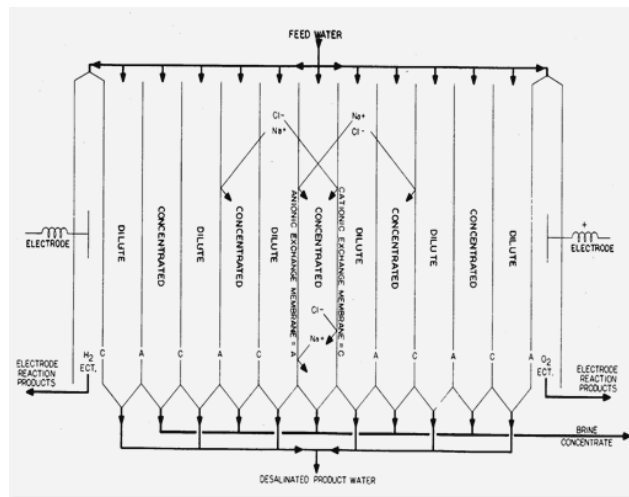


Figure 36 (Courtesy of The Complete Guide of Water Chemistry & Treatment)

Electrodialysis Reversal (EDR)

Similar to ED but the polarity is reversed periodically to move ions in the opposite direction.

Distillation

A purification process in which a liquid is evaporated and its vapor is condensed and collected. For water treatment, distillation is used as a desalting technique in such processes as multistage flash distillation, multiple-effect distillation, and vapor compression.



Figure 37 (Courtesy of MMA Sea Term 2014)

Lime softening

The process of removing water hardness by adding lime to precipitate solids composed of metal carbonates and hydroxides. Clarification may or may not also occur.

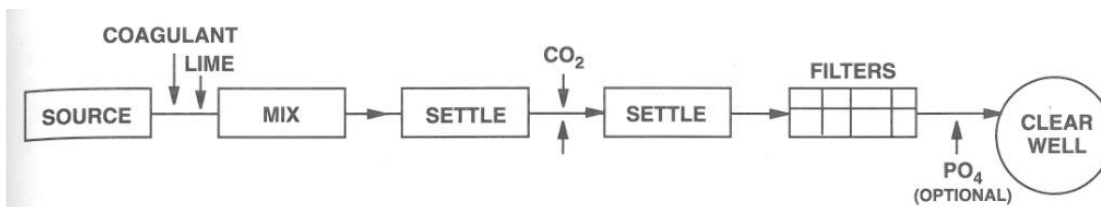


Fig. 14.2 Straight lime treatment

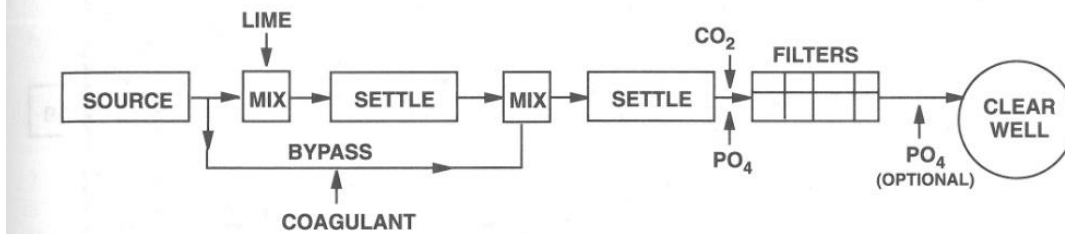


Fig. 14.3 Split lime treatment

Figure 38 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

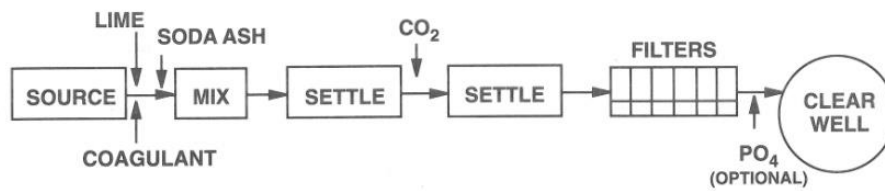


Fig. 14.5 Lime-soda ash treatment

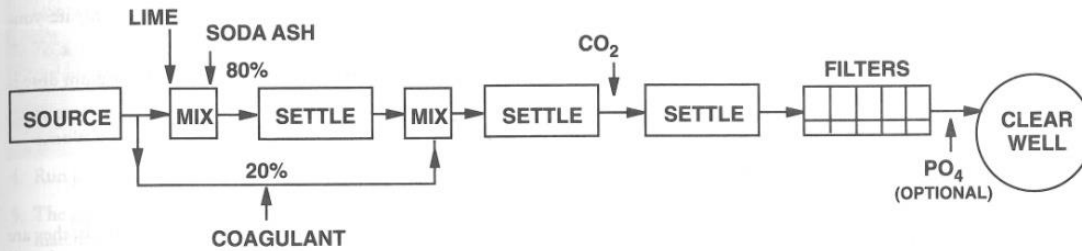
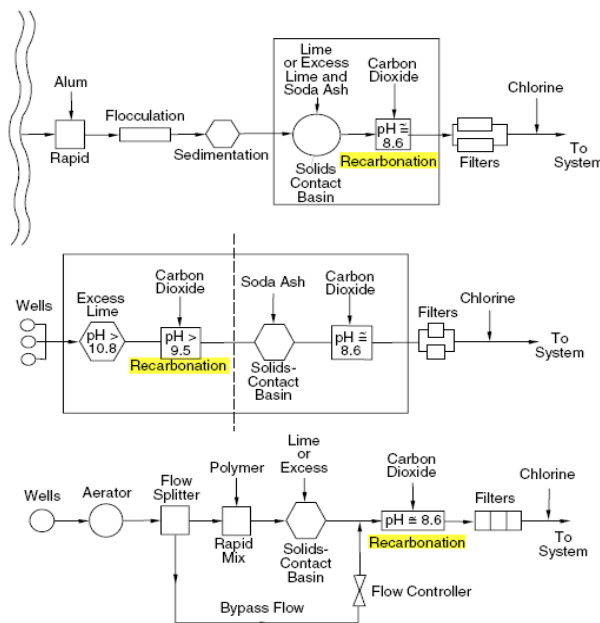


Fig. 14.6 Lime-soda ash split treatment

Figure 39 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

Recarbonation

The introduction of carbon dioxide (CO_2) into the water, after precipitative softening using excess lime for magnesium removal, to lower the pH of the water.



Types of lime-soda ash softening process

Figure 40 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

Fluoridation

The process of adding fluoride to water to help prevent tooth decay.

- ◆ **Sodium fluoride saturator:** A piece of equipment that feeds a sodium fluoride (NaF) solution into water for fluoridation. A layer of sodium fluoride is placed in a plastic tank and water is allowed to

trickle through the layer, forming a constant-concentration solution that is fed to the water system.

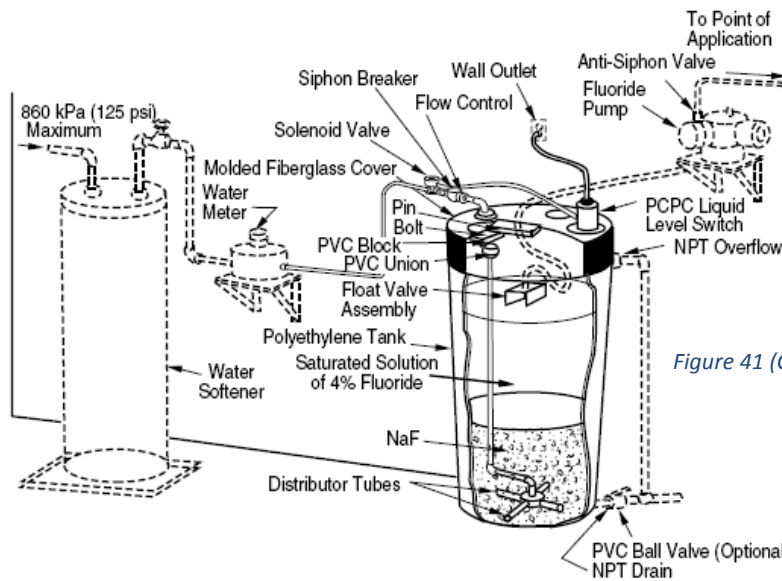


Figure 41 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- ◆ **Sodium silicofluoride (Sodium fluorosilicate):** The most inexpensive chemical available for fluoridation. It is a white or yellowish-white crystalline powder with limited solubility in water; therefore, it is usually dry fed.

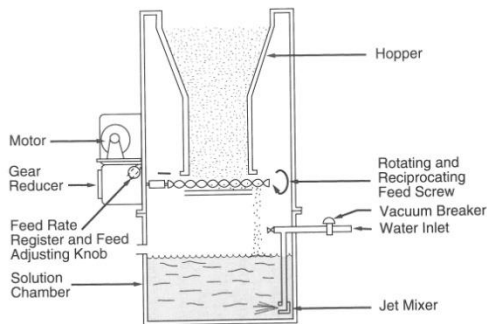


FIGURE 8-1 Screw-type volumetric dry feeder

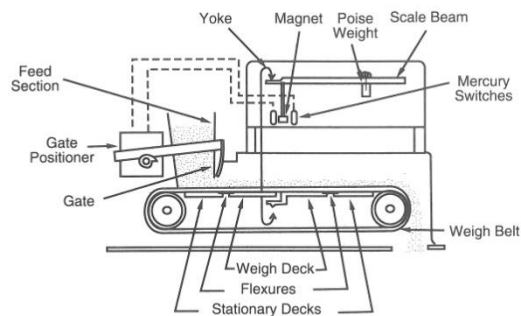


FIGURE 8-3 Belt-type gravimetric dry feeder

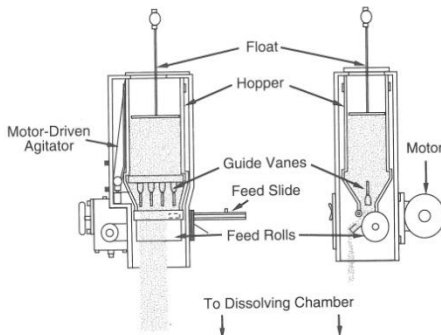


FIGURE 8-2 Roll-type volumetric dry feeder

Figure 42 [8-1, 8-2, 8-3] (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- ◆ **Hydrofluorosilic acid (Fluorosilicic acid):** A clear, colorless to straw-yellow colored, fuming, very corrosive liquid used for fluoridation.

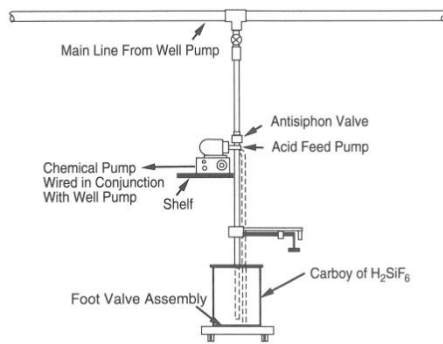


FIGURE 8-7 Acid feed installation

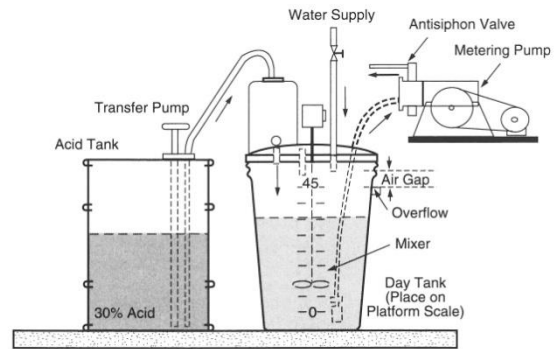


FIGURE 8-8 Diluted-acid feed system

Figure 43 [8-7, 8-8] (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

Disinfection

- ◆ **Chlorination:** An oxidation process that is initiated through the addition of chlorine. In chlorination, chlorine oxidizes microbiological material, organic compounds, and inorganic compounds. Chlorination is the principal form of disinfection in US water supplies.
 - **Powered or liquid hypochlorites.**
 - Chlorination using solutions of calcium hypochlorite ($\text{Ca}(\text{OCl})_2$) or sodium hypochlorite (NaOCl).

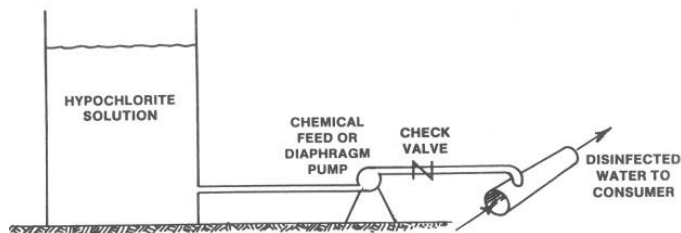
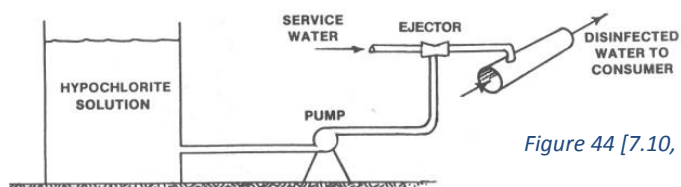


Fig. 7.10 Hypochlorinator direct pumping system



NOTE: Pump is chemical feed or diaphragm pump.

Fig. 7.11 Hypochlorinator injector feed system

Figure 44 [7.10, 7.11] (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)

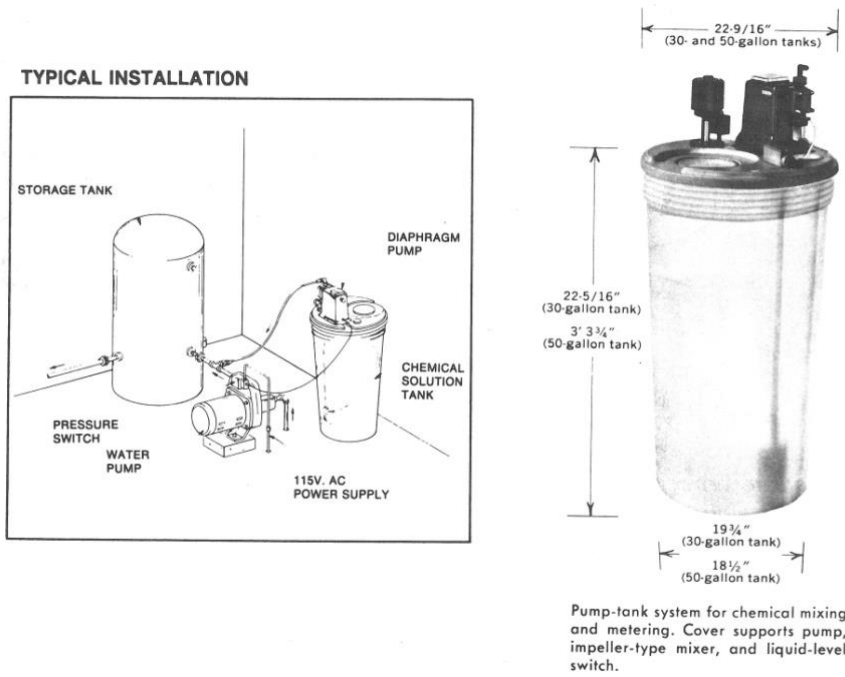


Fig. 7.7 Typical hypochlorinator installation
(Permission of Wallace & Tiernan Division, Pennwalt Corporation)

Figure 45 (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)

- **On-site generation of hypochlorites:** Hypochlorites can be generated on-site by combining salt, water, and electricity.

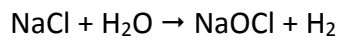


Figure 46 (Courtesy of Golden Heart Utilities Fairbanks, Alaska)

OSEC® FLOW DIAGRAM

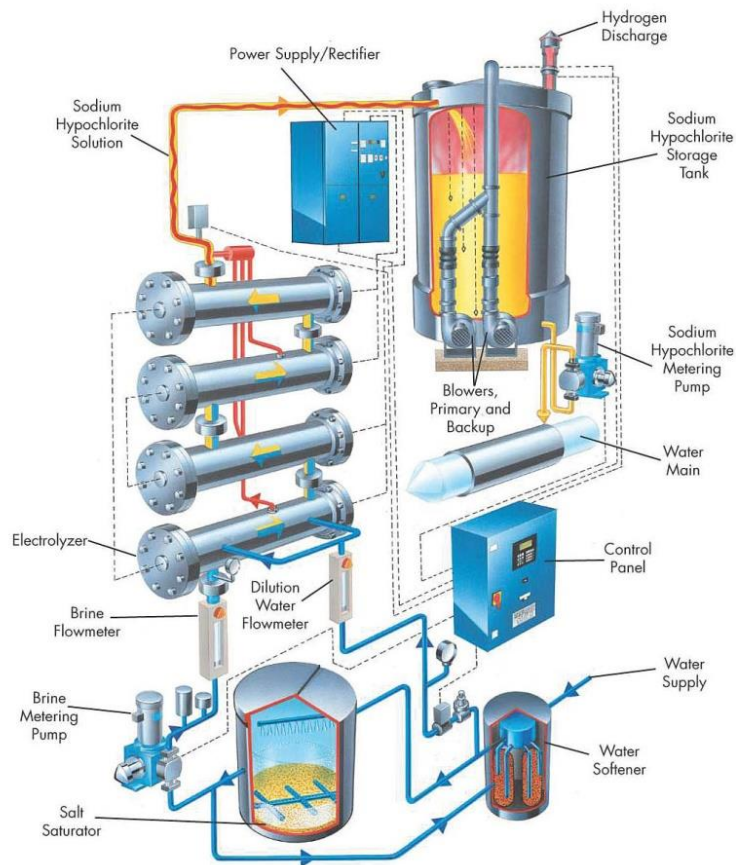
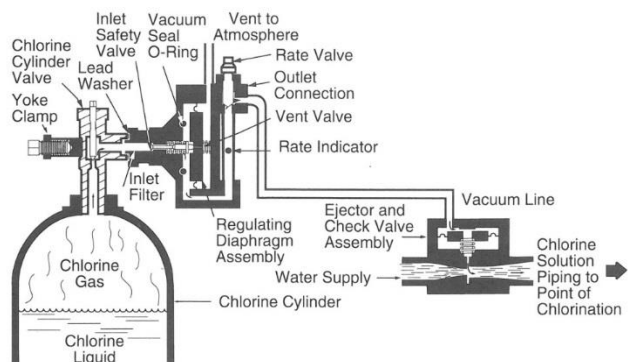


Figure 47 (Courtesy of Wallace & Tiernan OSEC On-Site Hypochlorite Generation Systems)

- **Gas chlorine:** Gaseous molecular chlorine (Cl_2), when introduced into water, is converted into hypochlorous acid (HOCl) and the hypochlorite ion (OCl^-); the ratio of the two substances is dependent on the pH of the solution ($\text{HOCl} \rightleftharpoons \text{OCl}^- + \text{H}^+$).



Courtesy of Severn Trent Services

FIGURE 7-27 Schematic of direct-mounted gas chlorinator

Figure 48 (Courtesy of Severn Trent Services)

- *Chlorination using tablets:* Tablets usually containing 70% available chlorine are placed a feeder which disinfect the water.

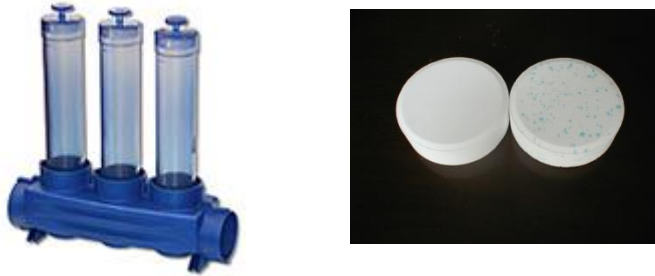


Figure 49 (Courtesy of Bio-Dynamic)

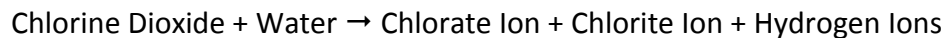
- *Chloramination:* Disinfecting water by using chloramines. Chloramines are produced by mixing chlorine (Cl₂) and ammonia (NH₃). Ammonia can be added either in liquid or gas form.

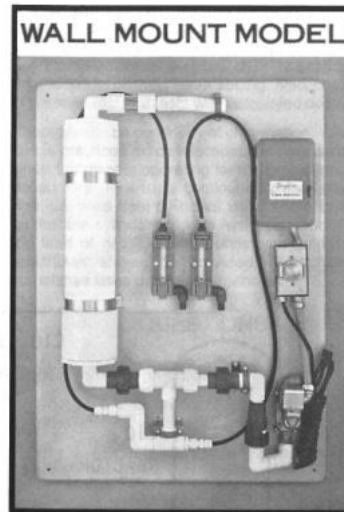
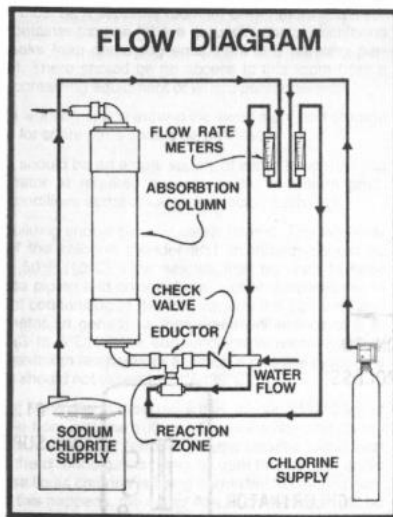


- *Chloramines can be produced by the following methods:*

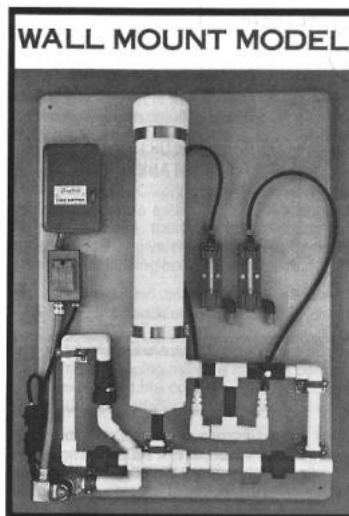
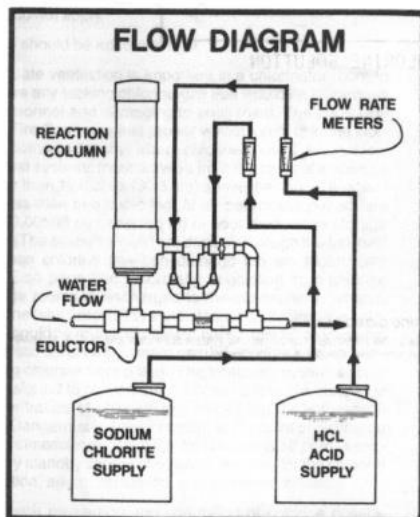
- *Preammoniation followed by chlorination:* Ammonia is applied at the rapid-mix unit process and chlorine is added downstream at the entrance to the flocculation basin.
- *Concurrent addition of chlorine and ammonia:* Chlorine is added to the plant influent and at the same time or immediately after ammonia is added at the rapid-mix unit process.
- *Prechlorination/Postammoniation:* Chlorine is added at the head of the plant and a free chlorine residual is maintained throughout the plant processes. Ammonia is added at the plant effluent to produce chloramines.

- *Chlorine Dioxide:* A red-yellow gas that is very reactive and unstable. It is a strong oxidizing agent and is also used as a disinfectant. Chlorine dioxide decomposes in water to yield the chlorite ion (ClO₂⁻) and, to a lesser extent, the chlorate ion (ClO₃⁻).





Chlorine-Chlorite Process (see Figure 7.34)



Acid-Chlorite Process

Fig. 7.35 Methods of generating chlorine dioxide
(Permission of Rio Linda Chemical Company)

Figure 50 (Courtesy of Rio Linda Chemical Company)

- ◆ **UV light:** The use of a UV light system to conduction disinfection. UV rays inactivate microorganisms that may be present in the water.

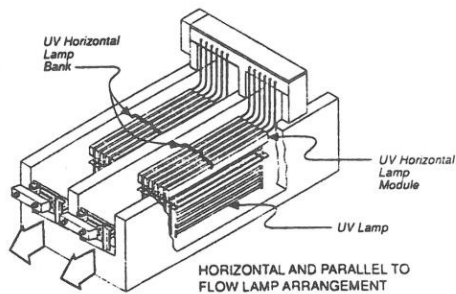
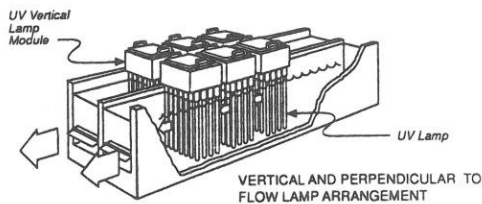
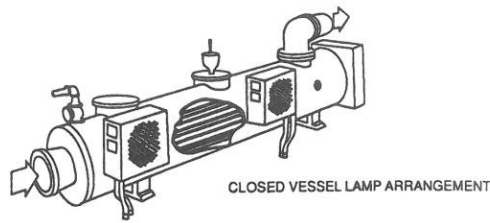


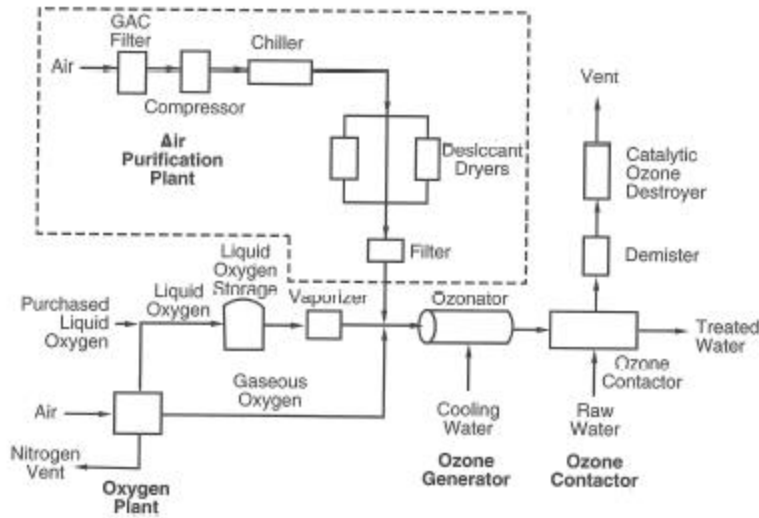
Figure 51 (Courtesy of "Ultraviolet Disinfection")

Fig. A-10.2 Typical UV lamp configurations
 (Source: "Ultraviolet Disinfection," by CH2M Hill, reproduced with permission of CH2M Hill)

- ◆ **Ozonation:** The application of ozone to disinfect the water. Ozone must be generated on-site because it decomposes to oxygen (O_2) in a short time after generation. Ozone is produced when O_2 molecules are exposed to an energy source and converted to O_3 (an unstable gas). O_3 is a very strong oxidant and virucide.



Figure 52 (Courtesy of Absolute Ozone - Water Treatment System)



Source: Water Quality and Treatment, 4th ed. (1990).

FIGURE 7-40 Flow diagram for air and oxygen purification for ozone production

Figure 53 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- ◆ **Chlor-Alkali Process:** The process of producing chlorine, sodium hydroxide (caustic soda), and hydrogen gas by electrolysis of a brine consisting of sodium chloride (NaCl).

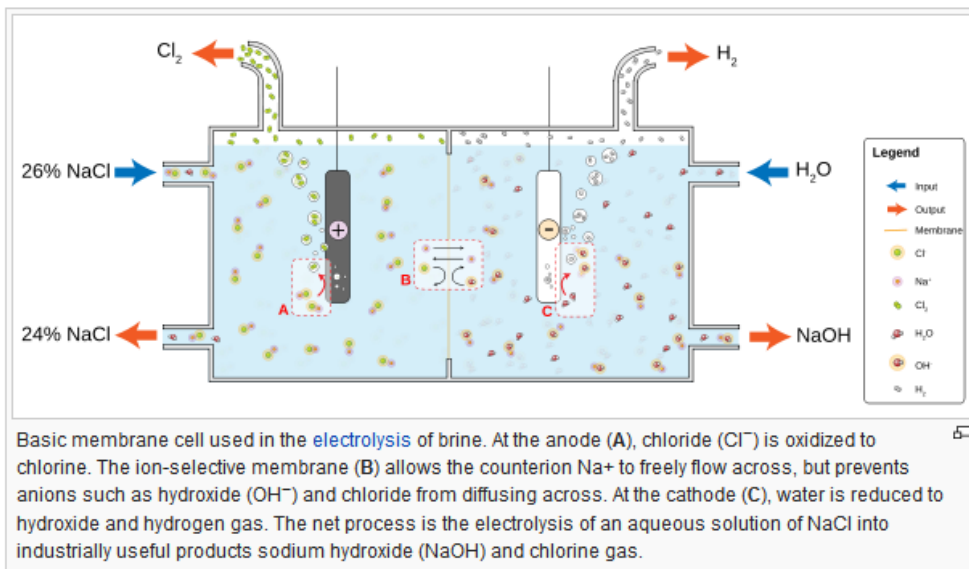


Figure 54 (Courtesy of Wikipedia)

On-site treatment of system sludge or backwash

The treatment of water results in process waste mainly sludge and waste water from filter backwashes. These wastes can be disposed of or treated in the following ways.

- ◆ Discharged to the sewer or another off-site location which could include the community wastewater lagoon.
- ◆ Discharged to an on-site pond, lagoon, or septic tank which is designed specifically to only accommodate filter backwash and sludge.
- ◆ The sludge can be mechanically dewatered prior to disposal by a belt filter press, a centrifuge, a filter press, or a vacuum filter.

Figure Index

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- Figure 5 (Courtesy of Nikolay Voutchkov © 2011)
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