Water Treatment & Processing Systems

Of GOGANI Company.

سیستمهای تصفیه و فرآوری آب

شرکت گوگانی

Web site : www.gogani.com
Email : info@gogani.com
Tel : +98 914 30 25 323 , +98 (0) 411 476 65 78
Address :Iran-Tabriz, Postal Box 51385-3454

تجهیزات قابل ارائه شرکت گوگانی برای تصفیه و پالایش انواع آب با کاربردهای مختلف تماما با نظارت و مهندسی شرکت گوگانی در خارج از ایران ساخته می شوند . طبقه بندی انواع آب و انواع روشهای تصفیه آب در ادامه این کاتالوگ به زبان انگلیسی موجود می باشد. دراین کاتالوگ فقط به تجهیزاتی که توسط شرکت ارائه می شود بصورت مختصر می پردازیم.

1. ماشین آلات و خطوط تولید تولید انواع آب داروی سازی Bio Pharmaceutical Water :

	FDA	GMP	
1	Non-potable	Potable Water	1
2	Potable (drinkable) water	Water for Injections	2
3	USP purified water	Purified Water	3
4	USP water for injection (WFI)	Water for preparation of extracts	4
5	USP sterile water for injection	------------	
6	LUSP sterile water for inhalation	------------	
7	USP bacteriostatic water for injection	------------	
8	USP sterile water for irrigation	------------	
https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/inspection-technical-guides/water-pharmacuetical-use		مستند طبقه بندی اروپایی پیوست این کاتالوگ می باشد	

2. ماشین آلات بازیافت انواع آب Water Recovery Equipment :

این تجهیزات برای بازیافت آب از پسآب و فاضلاب واحد های تولیدی شهرک های صنعتی کاربر دارد. و از ظرفیت های 500 لیتر در ساعت شروع می شوند وبرای ظرفیت های بالا محدودیتی نمی باشد.

3. آب شیرین کن با انواع ممبران RO :

این تجهیزات برای جداسازی انواع یون های محلول در آب کاربرد دارد. و امروزه در بازار و صنعت متداول می باشند. هزینه بالای نگهداری از معایب این نوع آب شیرین کن های می باشند.

4. تصفیه بیولوژیکی آب های خاص :

در این روش آب های آلوده به میکروارگانیسم های مضر و غیر مضر توسط میکروارگانیسمهای مفید دیگر بی اثر و حذف می شوند، البته برای پاک سازی (و یا جداسازی) یکسری آلودگی های (مواد ؛ عناصر و غیره) غیربیولوژیکی نیز از این روش استفاده می شود.

5. آب شیرین کن های مگا برای شهر و غیره :

این نوع آب شیرین کن ها معمولا آب دریا را تبدیل به آب آشامیدنی می کنند و برای شهر و کشاورزی ومصارف بالا استفاده می شوند، شرکت گوگانی با بهره گیری از دانش فنی شرکت های اروپایی با استفاده از پیشرفته ترین و ارزانترین روش برای شیرین کردن آب دریا ساخت و فروش این نوع آب شیرین کن ها را انجام می دهد.

13 November 2018
EMA/CHMP/CVMP/QWP/496873/2018

Committee for Medicinal Products for Human Use (CHMP)
Committee for Medicinal Products for Veterinary Use (CVMP)

Guideline on the quality of water for pharmaceutical use

Draft

Draft agreed by Quality Working Party	7 June 2018
Adopted by CHMP for release for consultation	28 June 2018
Adopted by CVMP for release for consultation	19 July 2018
Start of public consultation	15 November 2018
End of consultation (deadline for comments)	15 May 2019

This guideline replaces the Note for guidance on quality of water for pharmaceutical use (CPMP/QWP/158/01 EMEA/CVMP/115/01) and CPMP Position Statement on the Quality of Water used in the production of Vaccines for parenteral use (EMEA/CPMP/BWP/1571/02 Rev.1).

Comments should be provided using this template. The completed comments form should be sent to QWP@ema.europa.eu

Keywords	Guideline, water for injection, purified water, Ph. Eur.

30 Churchill Place ● Canary Wharf ● London E14 5EU ● United Kingdom
Telephone +44 (0)20 3660 6000 Facsimile +44 (0)20 3660 5555
Send a question via our website www.ema.europa.eu/contact

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Guideline on the quality of water for pharmaceutical use

Table of contents

Executive summary

This guideline replaces the Note for Guidance on quality of water for pharmaceutical use (CPMP/QWP/158/01, EMEA/CVMP/115/01) originally adopted in May 2002, and the CPMP Position Statement on the Quality of Water used in the production of Vaccines for parenteral use (EMEA/CPMP/BWP/1571/02 rev.1).

The note for guidance has been updated to reflect the following changes in the European Pharmacopoeia:

- revised monograph for Water for Injections (0169) allowing the possibility to use methods other than distillation for producing water of injectable quality;
- new monograph for Water for preparation of extracts (2249);
- suppression of the monograph for Water, highly purified (1927).

1. Introduction (background)

Water is one of the major commodities used by the pharmaceutical industry. It may be present as an excipient or used for reconstitution of products, during synthesis, during production of the finished product or as a cleaning agent for rinsing vessels, equipment, primary packaging materials etc.

Different grades of water quality are required depending on the different pharmaceutical uses. Control of the quality of water, in particular the microbiological quality, is a major concern and the pharmaceutical industry devotes considerable resource to the development and maintenance of water purification systems.

The European Pharmacopoeia (Ph. Eur.) provides quality standards for grades of water for pharmaceutical use including Water for Injections (WFI), Purified Water and Water for preparation of extracts.

Until April 2017, the production of Water for Injections (WFI) had been limited to production by distillation only. Following extensive consultation with stakeholders, the Ph. Eur. monograph for Water for Injections (0169) was revised in order to allow the production of WFI by a purification process equivalent to distillation, such as reverse osmosis coupled with appropriate techniques such as electro-deionisation, ultrafiltration or nanofiltration. The revised monograph was published in the Ph. Eur. Supplement 9.1 and became effective on 1 April 2017.

This change brings the Ph. Eur. more closely in line with the US Pharmacopeia and the Japanese Pharmacopoeia, allowing production of WFI by distillation or by a purification process proven “equivalent or superior to distillation”, and “by distillation or by reverse osmosis and/or ultrafiltration”, respectively.

In addition, the Ph. Eur. Commission has adopted a new policy for the test for bacterial endotoxins, reflected in the revision of general chapter 5.1.10 Guidelines for using the test for bacterial endotoxins and the general monograph for Substances for pharmaceutical use (2034). As a consequence, new monographs for substances for pharmaceutical use will no longer include the test for bacterial endotoxins (with possible exceptions). This aspect is now covered by the general monograph, which includes recommendations for establishing limits and information on how to evaluate the pyrogenicity of substances and where, according to the monographs on Parenteral preparations (0520) and Preparations for irrigation (1116), the requirements apply to the finished product.

The opportunity has also been taken to update terminology and requirements to reflect current expectations.

2. Scope

This document is intended to provide guidance to the industry on the pharmaceutical use of different grades of water in the manufacture of active substances and medicinal products for human and veterinary use and should be considered for new marketing authorisation applications, as well as any relevant variation application to existing marketing authorisations.

This guidance also applies to Advanced Therapy Medicinal Products (ATMPs). Where applicable, guidance is provided to include preparation of critical starting materials such as viral vectors and on cell based medicinal products where terminal sterilisation is not possible. For additional specific guidance for Advanced Therapy Medicinal Products, applicants and manufacturers are advised to consult the EC guidelines on Good Manufacturing Practice (GMP) specific to Advanced Therapy Medicinal Products (ATMPs).

Where relevant, the principles of this guideline may also be applied to investigational medicinal products.

This guidance is not intended to cover situations where medicinal products are prepared extemporaneously or where preparations are reconstituted/diluted with water prior to use by a pharmacist (e.g. water for reconstituting oral antibiotic mixtures, water for diluting haemodialysis solutions) or in the case of veterinary products, by the user (e.g. sheep dips).

This guideline complements the “Questions and answers on production of water for injections by non-distillation methods – reverse osmosis and biofilms and control strategies EMA/INS/GMP/443117/2017 GMP/GDP Inspectors Working Group” which has been published following the implementation of the revised monograph for Water for Injections (0169) and it is intended that the guideline and Q&A should be read together.

3. Legal basis

This guideline has to be read in conjunction with the introduction and general principles sections 4 & 5 of Annex I to Directive 2001/83/EC and the introduction and general principles section 2 & 3 of Annex I to Directive 2001/82/EC.

4. Requirements of the European Pharmacopoeia

The European Pharmacopoeia provides quality standards for the following grades of water:

- Water for Injections
- Purified Water
- Water for preparation of extracts

4.1. Potable Water

Potable Water is not covered by a pharmacopoeial monograph but must comply with the regulations on water intended for human consumption of a quality equivalent to that defined in Directive 98/83/EC, or laid down by the competent authority. Testing should be carried out at the manufacturing site to confirm the quality of the water. Potable water may be used in chemical synthesis and in the early stages of cleaning pharmaceutical manufacturing equipment unless there are specific technical or quality requirements for higher grades of water. It is the prescribed source feed water for the production of pharmacopoeial grade waters.

4.2. Water for Injections (WFI)

Water for Injections (WFI) is water for the preparation of medicines for parenteral administration when water is used as a vehicle (water for injections in bulk) and for dissolving or diluting substances or preparations for parenteral administration (sterilised water for injections).

For a detailed description of the production and control of Water for Injections refer to Ph. Eur. monograph 0169. It should be noted that when reverse osmosis is to be introduced at the local manufacturing site, notice should be given to the GMP supervisory authority of the manufacturer before implementation as described in the *Compilation of Community Procedures on Inspections and Exchange of Information*.

4.3. Purified Water

Purified Water is water for the preparation of medicines other than those that are required to be both sterile and apyrogenic, unless otherwise justified and authorised.

Purified Water which satisfies the test for endotoxins described in Ph. Eur. monograph 0008 may be used in the manufacture of dialysis solutions.

For a detailed description of the production and control of Purified Water refer to Ph. Eur. monograph 0008.

4.4. Water for preparation of extracts

Water for preparation of extracts is water intended for the preparation of Herbal drug extracts (0765) which complies with the sections Purified water in bulk or Purified water in containers in the monograph Purified water (0008), or is water intended for human consumption of a quality equivalent to that defined in Directive 98/83/EC which is monitored according to the Production section described in the monograph.

For a detailed description of the production and control of Water for preparation of extracts refer to Ph. Eur. Monograph 2249.

5. Quality of Water for Pharmaceutical Use

Validation and qualification of water purification, storage and distribution systems are a fundamental part of GMP and form an integral part of the GMP inspection.

The grade of water used at different stages in the manufacture of active substances and medicinal products should be discussed in the marketing authorisation application. The grade of water used should take account of the nature and intended use of the finished product and the stage at which the water is used.

The following tables provide some general examples for guidance:

5.1. Water present as an excipient in the final formulation

Water is the most commonly used excipient in medicinal products: the minimum quality of water selected depends on the intended use of the product, according to a risk based approach to be applied as part of an overall control strategy.

Table 1 summarises the main categories of sterile products. WFI is required for those products intended for parenteral administration and this includes solutions for haemofiltration and haemodiafiltration, and peritoneal dialysis.

Sterile ophthalmic, nasal/ear and cutaneous preparations should be prepared using materials (water) designed to ensure sterility and to avoid the introduction of contaminants and the growth of micro-organisms. According to the risk assessment, this could require the use of water of higher quality than purified water.

Table 1: Sterile Medicinal Products

Sterile medicinal products	Minimum acceptable quality of water
Biologics (including vaccines and ATMP)	WFI
Parenteral	WFI
Ophthalmic (excluding ATMP)	Purified Water
Haemofiltration Solutions Haemodiafiltration Solutions	WFI
Peritoneal Dialysis Solutions	WFI
Irrigation Solutions	WFI
Nasal/Ear Preparations	Purified Water
Cutaneous Preparations	Purified Water

Table 2 summarises the main categories of non-sterile dosage forms. With the exception of non-sterile vaccines for non-parenteral use and some nebuliser preparations, Purified Water is the acceptable grade of water for all non-sterile products.

Table 2: Non-sterile Medicinal Products

Non-sterile medicinal products	Minimum acceptable quality of water
Vaccines for non-parenteral use	Purified Water*
Oral Preparations	Purified Water
Nebuliser Solutions	Purified Water**
Cutaneous Preparations	Purified Water***
Nasal/Ear Preparations	Purified Water
Rectal/Vaginal Preparations	Purified Water

* WFI is recommended in order to ensure the vaccines' safety and product quality (avoid introduction of undesirable microorganisms in the finished product formulation) unless otherwise justified (i.e. for some non-sterile veterinary vaccines for non-parenteral use, purified water might be accepted).

** In certain disease states (eg. cystic fibrosis), medicinal products administered by nebulisation are required to be sterile and non-pyrogenic. In such cases, WFI should be used.

*** For some products such as veterinary teat dips, it may be acceptable to use potable water where justified and authorised taking account of the variability in chemical composition and microbiological quality.

5.2. Water used during manufacture of active substances and medicinal products excluding water present as an excipient in the final formulation

The acceptable grade of water will depend heavily on the stage at which it is to be used during manufacture, the subsequent processing steps and the nature of the final product, according to a risk based approach to be applied as part of an overall control strategy.

Table 3 summarises the minimum acceptable quality of water for the manufacture of active substances.

Table 3: Water used during the manufacture of Active Substances (AS)

Type of manufacture	Product requirements	Minimum acceptable quality of water
Synthesis of all intermediates of AS prior to final isolation and purification steps	No requirement for sterility or apyrogenicity in AS or the pharmaceutical product in which it will be used.	Potable Water*
Fermentation media	AS is intended for manufacturing of chemical entities (i.e. semi-synthetic products, antibiotics).	Potable Water*
Fermentation media and cell culture media	AS is intended for manufacturing of biologics (i.e. vaccines and recombinant biologicals).	Purified Water
All steps including fermentation media, cell culture media, initial purification, final isolation and purification.	AS is intended for manufacturing of ATMPs. Also applicable to starting materials such as viral vectors intended for the manufacture of ATMPs.	WFI
Extraction of herbals	No requirement for sterility or apyrogenicity in AS or the pharmaceutical product in which it will be used	Water for preparation of extracts **
Any step excluding final isolation and purification (e.g. fermentation, initial purification)	AS is biological and intended for parenteral use (excluding ATMP).	Purified Water
Final isolation and purification	No requirement for sterility or apyrogenicity in AS or the pharmaceutical product in which it will be used.	Potable Water*
Final isolation and purification	AS is not sterile, but is intended for the preparation of non-sterile vaccines for non-parenteral use.	Purified Water
Final isolation and purification	AS is not sterile, but is intended for use in a sterile, non-parenteral product.	Purified Water
Final isolation and purification	AS is sterile and not intended for parenteral use.	Purified Water
Final isolation and purification	AS is not sterile, but is intended for use in a sterile, parenteral product.	Purified Water***

Type of manufacture	Product requirements	Minimum acceptable quality of water
Final isolation and purification	AS (biological) is in solution, not sterile, but is intended for use in a sterile, parenteral product.	WFI
Final isolation and purification	AS is sterile and apyrogenic	WFI
Final purification	AS is biological and intended for parenteral use.	WFI

* Purified Water should be used where there are technical requirements for greater chemical purity.

** Refer to the monograph 2249 “Water for preparation of extracts”.

*** Appropriate specifications have to be set for endotoxins and specified micro-organism testing of the active substance as per the relevant Ph. Eur. chapters.

Table 4 summarises the acceptable quality of water for the manufacture of sterile and non-sterile medicinal products.

Table 4: Water used during manufacture of medicinal products but not present in the final formulation

Manufacture	Minimum acceptable quality of water
Granulation	Purified Water*
Tablet coating	Purified Water
Used in formulation prior to non-sterile lyophilisation	Purified Water
Used in formulation prior to sterile lyophilisation	WFI

* For some veterinary premix products eg. granulated concentrates it may be acceptable to use potable water where justified and authorised taking account of the variability in chemical composition and microbiological quality.

5.3. Water used for cleaning/rinsing of equipment, containers and closures

Washing procedures of the equipment, primary containers and closures normally fall within the field of GMP and are not described routinely in the MA dossier, but may, in certain circumstances, be requested by the competent authority.

In general, the final rinse used for equipment, containers/closures should use the same quality of water as used in the final stage of manufacture of the AS or used as an excipient in a medicinal product.

Table 5 summarises the acceptable quality of water used for cleaning/rinsing of equipment, containers/closures for all medicinal products.

Table 5: Water used for cleaning/rinsing.

Cleaning/Rinsing of Equipment, Containers, Closures	PRODUCT TYPE	Minimum Acceptable quality of water
Initial rinse	Intermediates and AS	Potable Water
Final rinse	AS	Use same quality of water as

Cleaning/Rinsing of Equipment, Containers, Closures	PRODUCT TYPE	Minimum Acceptable quality of water
		used in the AS manufacture
Initial rinse including CIP* of equipment, containers and closures, if applicable.	Medicinal products – non sterile	Potable Water
Final rinse including CIP* of equipment, containers and closures, if applicable.	Medicinal products – non sterile	Purified Water or use same quality of water as used in manufacture of medicinal product, if higher quality than Purified Water
Initial** rinse including CIP* of equipment, containers and closures, if applicable.	Sterile products	Purified Water
Final rinse*** including CIP* of equipment, containers and closures, if applicable.	Sterile non-parenteral products	Purified Water or use same quality of water as used in manufacture of medicinal product, if higher quality than Purified Water
Final rinse*** including CIP* of equipment, containers and closures, if applicable.	Sterile parenteral products	WFI

* CIP = Clean In Place

** Some containers, e.g. plastic containers for eyedrops may not need an initial rinse, indeed this may be counter-productive since particulates counts could be increased as a result. In some cases e.g. blow-fill-seal processes rinsing cannot be applied.

*** If equipment is cleaned with diluted detergents or/and dried after rinsing with diluted alcohol, the alcohol or the detergent should be diluted in water of the same quality as the water used for the final rinse.

References

1. Note for Guidance on Quality of water for pharmaceutical use (CPMP/QWP/158/01-EMEA/CVMP/115/01).
2. Ph. Eur. monograph “Water for Injections” (0169).
3. Ph. Eur. monograph “Water for preparation of extracts” (2249).
4. Ph. Eur. monograph “Water, purified” (0008).
5. Ph. Eur. monograph “Parenteral preparations” (0520).
6. Ph. Eur. monograph “Preparations for irrigation” (1116).
7. Ph. Eur. monograph “Substances for pharmaceutical use” (2034) .
8. CPMP Position Statement on the Quality of Water used in the production of Vaccines for parenteral use (EMEA/CPMP/BWP/1571/02 Rev.1).
9. ICH Q9 (Quality risk management), EMA/CHMP/ICH/24235/2006.

10. Questions and answers on production of water for injections by non-distillation methods – reverse osmosis and biofilms and control strategies EMA/INS/GMP/443117/2017 GMP/GDP Inspectors Working Group.
11. Ph. Eur. chapter 5.1.10 "Guidelines for using the test for bacterial endotoxins"
12. Compilation of Community Procedures on Inspections and Exchange of Information, (EMA/572454/2014).

Alaska Department of Environmental Conservation
Operator Training and Certification Program

Wastewater System Classification Information

Updated November 2016

System Classification Information

Wastewater Stabilization Pond

- A wastewater treatment system which scores 1 – 30 points under the wastewater treatment point classification system and where a stabilization pond without aeration is the only means of secondary treatment.

Wastewater Collection and Wastewater Treatment Systems

- A public or private wastewater system that
  - Has ≥ 100 service connections, or
  - Serves ≥ 500 people per day.

System Classification Information

Wastewater Collection 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 gravity is the only means of wastewater flow are Class I systems regardless of the number of service connections*
- *Systems with 15 or more main line lift stations will be classified at one class higher than the class determined above*

System Classification Information

Wastewater 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

Pretreatment

- Influent pumping: 2
- Flow equalization basin: 1
- Manually cleaned screens: 1
- Mechanically cleaned screens: 2
- Fine screens, including microscreens: 3
- Comminutor, barminutor, grinders: 2
- Grit removal: 2

Primary Treatment

- Primary clarifiers: 4
- Primary clarifiers with chemical addition: 7
- Imhoff tank, or other method of combined sedimentation and digestion, other than a septic tank: 3
- Dissolved air flotation: 16

Secondary Treatment

- Trickling filter without recirculation: 5
- Trickling filter with recirculation: 8
- Activated sludge:
    - Oxidation ditch: 8
    - Diffused or dispersed aeration: 10
    - Pure oxygen: 15
    - Sequencing batch reactor (SBR), intermittent cycle extended aeration system (ICEAS), or other batch treatment method: 20
    - Additional points if an activated sludge plant is operated in high rate mode or contact stabilization mode: 2
- Rotating biological contactor: 10
- Activated bio-filter with aeration: 10
- Activated bio-filter without aeration: 8
- Stabilization ponds without aeration: 5
- Aerated lagoon: 8
- Secondary clarifiers: 4
- Secondary clarifiers with chemical addition: 7

Advanced Waste Treatment

- Polishing pond or effluent flow equalization:2
- Chemical and physical treatment without secondary treatment:20
- Chemical and physical treatment following secondary treatment: 15
- Ion exchange: 4
- Granular media filtration: 8
- Membrane filtration, including reverse osmosis, microfiltration, ultrafiltration, or nanofiltration: 8
- Membrane filtration, integrated system: 12
- Electrodialysis, electrodialysis reversal: 10
- Biological or combined chemical and biological nutrient removal: 12
- Nitrification by extended aeration only: 2
- Chemical precipitation of phosphorous: 3
- pH adjustment: 3
- Activated carbon columns or beds: 8

In-plant Odor Control (maximum of 6 points in any combination)

- Biofilter: 3
- Adsorption with activated carbon or equal adsorbent: 3
- Wet scrubber: 3
- Thermal deactivation with catalytic process: 6
- Odor-reducing sprays: 2

Sludge Thickening and Dewatering

- Sludge decant tank: 2
- Gravity thickener basin: 3
- Gravity belt thickener: 4
- Screw press: 5
- Centrifuge: 6
- Belt filter press, plate-and-frame press, or vacuum filter: 8
- Sludge bagger: 3
- Evaporative sludge drying by means of drying beds:2
    - Additional points if a polymer is added to sludge before the sludge is put in drying beds: 3

Sludge Stabilization and Conditioning

- Unheated anaerobic digestion: 8
- Heated anaerobic digestion: 10
- Aerobic digestion: 5
- Wet oxidation: 10
- Chemical stabilization with lime: 3
- In-vessel composting, if controlled and operated by the operator as part of routine systems operations: 10
- Static pile composting, if controlled and operated by the operator as part of routine system operations: 5

Solids Disposal

- Incineration, if controlled and operated by the operator as part of routine system operations: 12
- Land application, if controlled and operated by the operator as part of routine system operations: 5
- Sludge lagoon: 3
- Off-site disposal: 1

Disinfection

- Liquid and powdered hypochlorites: 3
    - Additional points if hypochlorites are generated on-site:2
- Gas chlorine: 12
- Chlor-alkali on-site generation: 12
- Chlorination using tablets: 1
- Ultraviolet light: 3
- Ozonation without pure oxygen: 3
- Ozonation with pure liquefied oxygen: 4
- Ozonation with on-site generation of pure oxygen: 5
- Dechlorination with gas: 10

- Dechlorination with chemical dechlorination agents other than gas: 3
- Dechlorination using tablets: 1

Effluent Discharge

- Plant pumping of effluent: 2
- Effluent aeration: 2

WWT Facility Component Information

Generic WWT Facility Flow Diagram

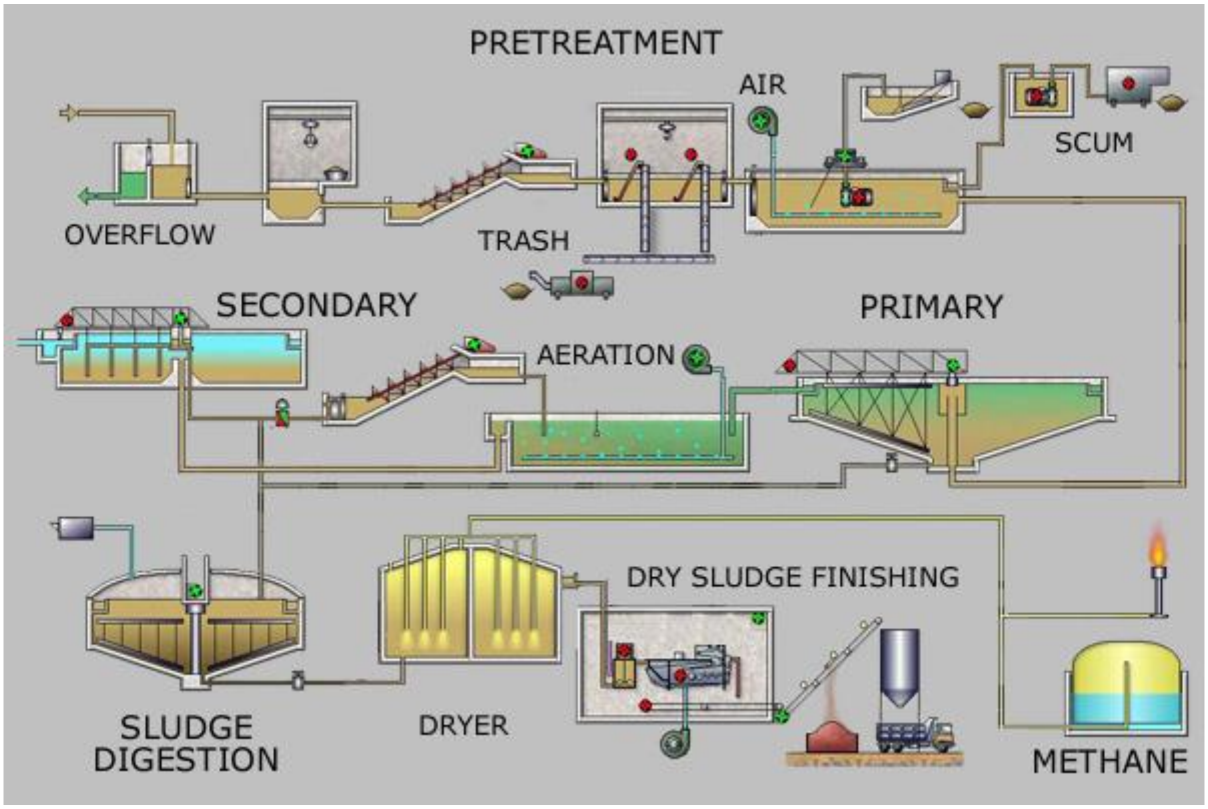


Figure 1 (Courtesy of Sustainable IIT Delhi)

Pretreatment

- *Influent pumping:* Wastewater is pumped to the plant instead of flowing via gravity.
- *Flow equalization basin:* A basin or tank where a portion of the wastewater is stored or held back during peak flows for release during low-flow periods.
- *Screens:* Device used to catch large debris such as rags, roots, wood, etc., to prevent damage to equipment. Can be either ***manually*** or ***mechanically*** cleaned.

Manually cleaned bar screen

Figure 2 (Courtesy of www.infobarscreens.com)

Mechanically cleaned bar screen

Figure 3 (Courtesy of China Chemnet)

Fine screen
Figure 4 (Courtesy of schreiberwater.com/FineScreen.shtml)

- *Comminutor or Barminutor or Grinder:* A device used to reduce solids chunks in wastewater by shredding, cutting, or grinding.

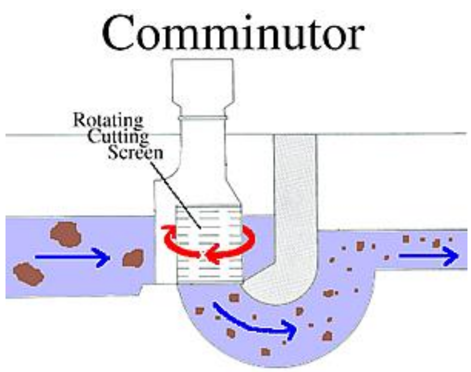


Figure 5 (Courtesy of water.me.vccs.edu)

Comminutor

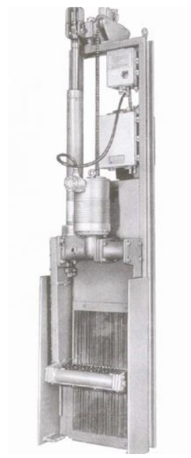


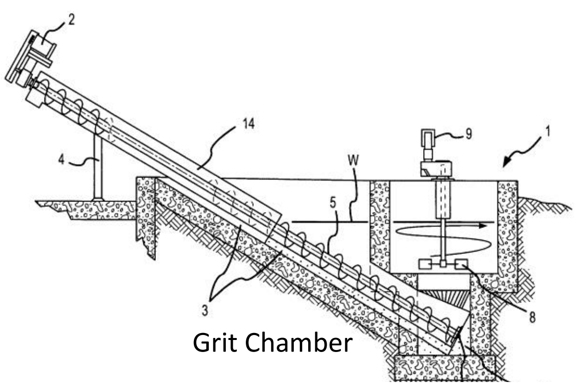
Figure 6 (Courtesy of CSU Operation of Wastewater Treatment Plants, Vol. 1; 7th ed.)

Barminutor

Figure 7 (Courtesy of sispaltd.com)

Grinder

- *Grit Removal:* Grit can be removed via a grit chamber or grit channel.



Grit Chamber

Figure 8 (Courtesy of Schloss Engineered Equipment, INC., CO.)

Grit Channel
Figure 9 (Courtesy of undermontreal.com/montreal-wastewater-treatment-plant/)

Primary Treatment

- *Primary Clarifier:* A sedimentation or settling tank that helps clarify or clear up the wastewater and located immediately after the bar screen, comminutor, or grit channel. Tanks can be square, rectangular, or circular.
    - *Chemical addition:*
        - Polymers to improve settling
        - Chlorine or potassium permanganate for odor control
        - Iron and aluminum compounds such as ferric chloride and alum, for phosphorus removal and improving settling

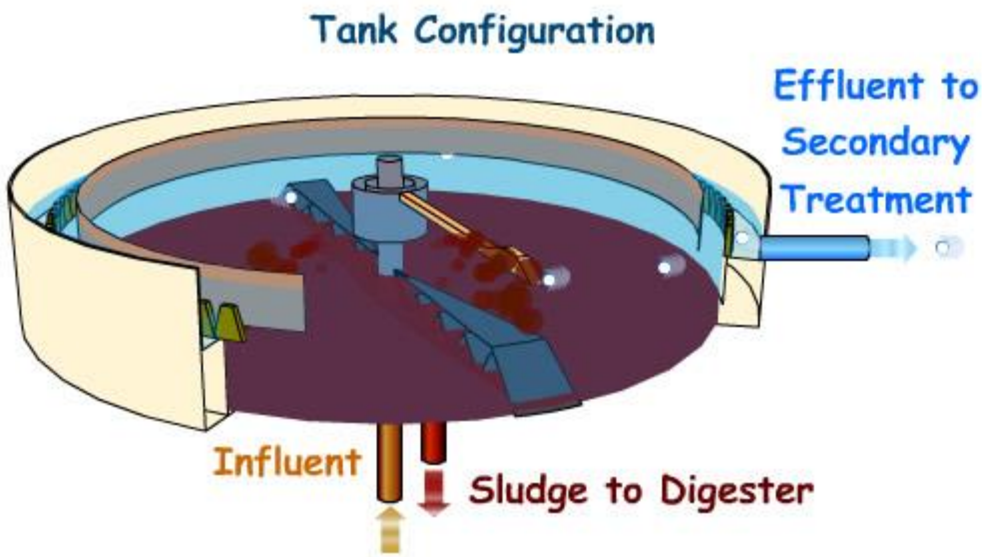


Figure 10 (Courtesy of techalive.mtu.edu/meec/module21/CSOs.htm)

- *Imhoff Tank:* Tank where settling occurs along with anaerobic digestion of the extracted sludge.

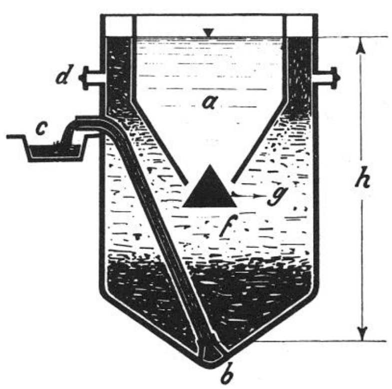
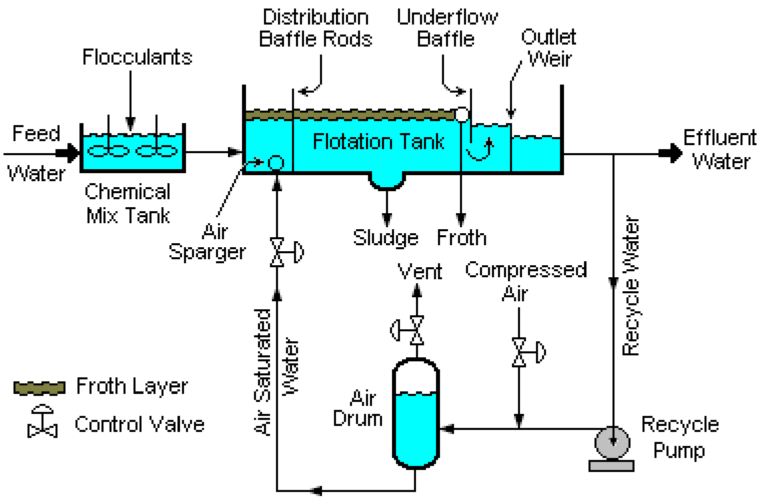


Figure 11 (Courtesy of commons.wikimedia.org/wiki/File:Emscherbrunnen.jpg)

- *Dissolved air flotation (DAF):* Process by which air is dissolved in water then released to atmospheric pressure in a flotation tank or basin. The air will float to the surface carrying solids which are then skimmed off. Heavier particles will sink to the bottom where they are removed by a sludge collector.



DAF Unit *Figure 12 (Courtesy of Mbeychok)*

Secondary Treatment

- *Trickling Filter:* Process by which wastewater trickles over media that provide the opportunity for the formation of slimes and biomass which contain organisms that feed upon and remove waste from the water being treated.

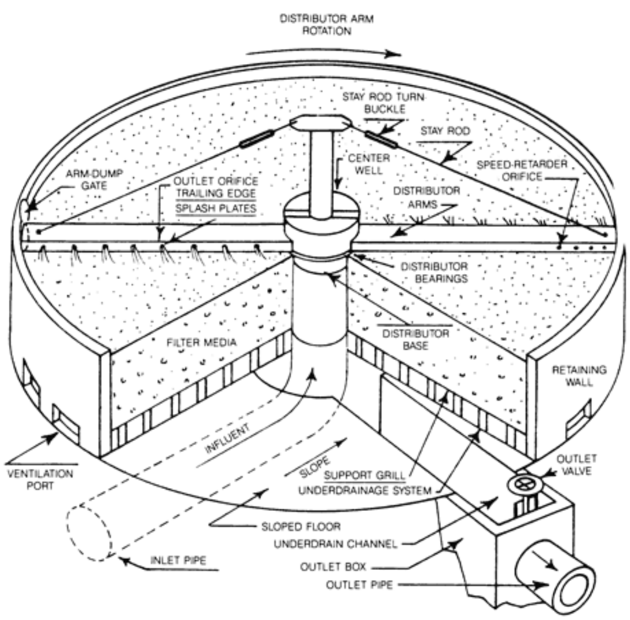


Figure 21.1 Trickling filter parts (California State, 1988)

Figure 13 (Courtesy of web.deu.edu.tr/atiksu/ana52/biofilm2.html)

Figure 14 (Courtesy of City of Portland)

- *Activated Sludge:*
    - *Oxidation Ditch:* Modified form of the activated sludge process where wastewater is treated in large round or oval ditches with one or more horizontal aerators, usually brushes.

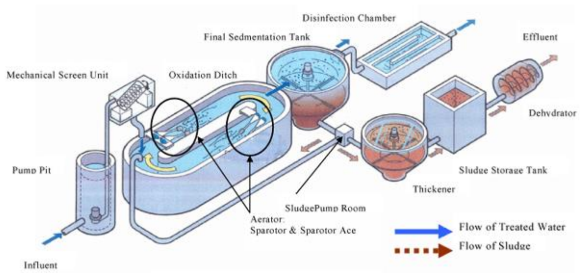


Figure 15 (Courtesy of Hitachi Oxidation Ditch System)

Figure 16 (Courtesy of wis-ni.com)

- *Diffused or dispersed aeration:* Injection of air or oxygen below the surface of the wastewater to enhance the oxygen supply to the activated sludge process and to mix aerobic components. Target DO of 2.0 to 4.0 mg/L.

Figure 17 (Courtesy of Ecosafe Solutions)

- *Pure oxygen:* An activated sludge process where O_2 is separated from air to produce high-purity O_2. O_2 is introduced to the wastewater by a diffuser or mechanical agitation. This process takes place in a gas tight enclosure.

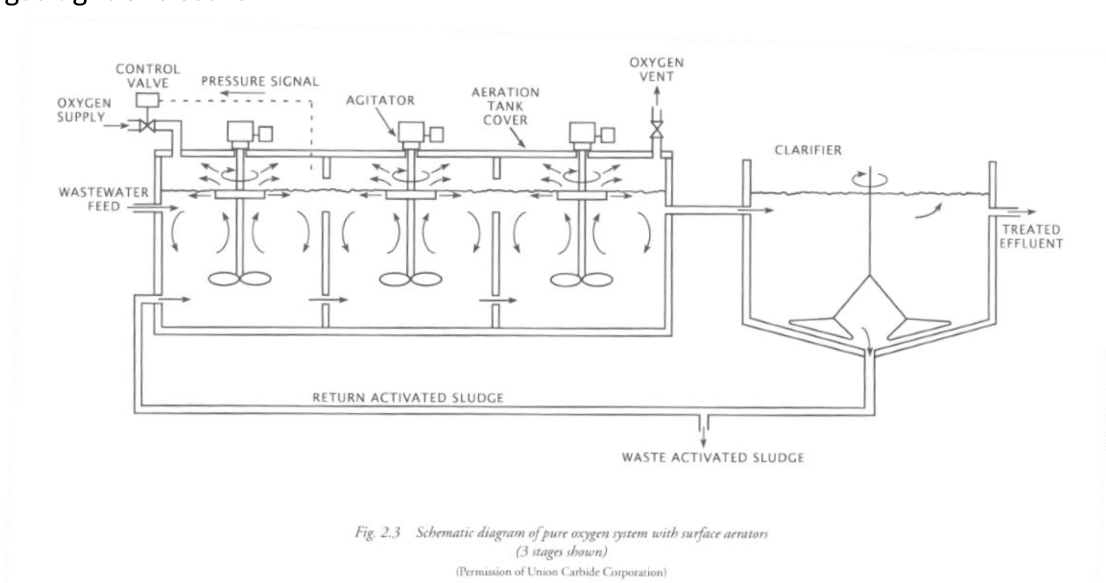


Figure 18 (Courtesy of Union Carbide Corporation)

- *Sequencing Batch Reactor (SBR):* An activated sludge process where aeration, sedimentation, and clarification takes place in one tank through sequencing stages.

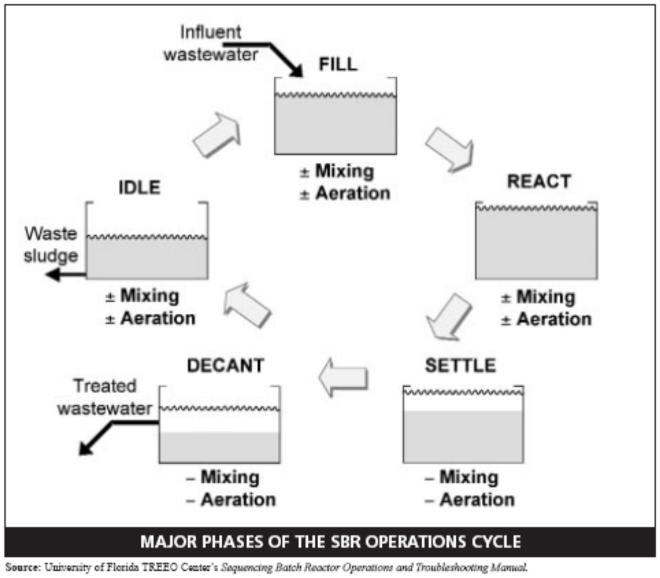


Figure 19 (Courtesy of University of Florida TREEO Comtec)

- *Intermittent Cycle Extended Aeration System (ICEAS):* A variation of the SBR process where there is continuous inflow in a single basin, even during settling and decant phases of the operating cycle.

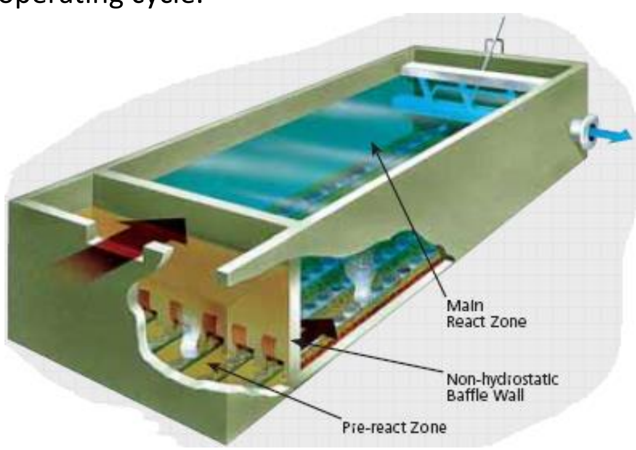


Figure 20 (Courtesy of Xylem, Inc.)

- *Contact Stabilization:* Return activated sludge (RAS) is fed to the head of the biological reactor and the influent wastewater is added downstream of the point of sludge addition.

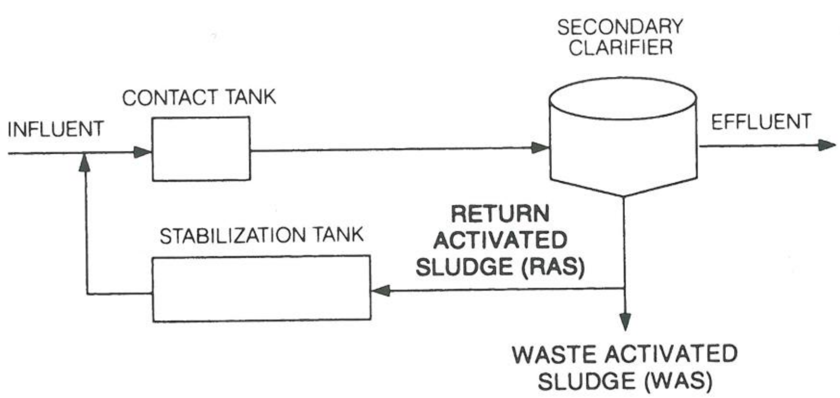


Figure 21 (Courtesy of WEF Operator of Municipal Wastewater Treatment Plants Vol. II Sixth Ed.)

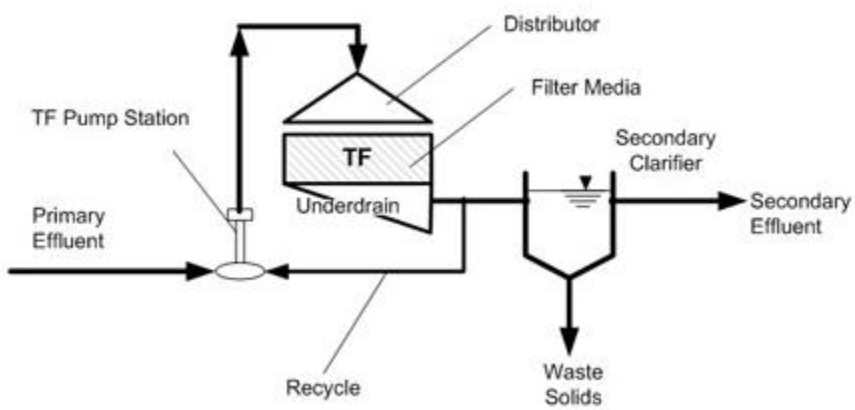
- *High Rate Mode:* An activated sludge plant that is being operated at the highest loading of food to microorganisms (sludge age ranges 0.5 to 2 days).

- *Rotating Biological Contactor (RBC):* RBCs have a rotating "shaft" surrounded by plastic disc called media. The shaft and media together are called the drum. A biological slime grows on the media when conditions are suitable. The microorganisms that make up the slime stabilize the waste products by using the organic material in the wastewater for growth and reproduction.

Figure 22(Courtesy of Skaneateles Wastewater Treatment Plant)

- *Activated Bio-filter:* This process uses a lightly loaded trickling filter with high-rate media. Biological or activated solids are recycled from the bottom of the secondary clarifier and returned to the trickling filter.

Figure 23 (Courtesy of Fixed Film Forum)



- *Stabilization Pond/Lagoon:* Shallow pond used for the treatment of wastewater. Ponds can be non-aerated or aerated.

Figure 24 (Courtesy of NPS Photo: Wind Cave National Park)

Non-aerated Lagoon

Figure 25 (Courtesy of University of British Columbia)

Aerated Lagoon

- *Secondary Clarifier:* A clarifier that is located after a biological treatment process.

Advanced Waste Treatment

- *Polishing Pond:* Ponds that are used in series after a trickling filter plant, thereby, giving tertiary treatment.
- *Effluent Flow Equalization:* Use of an equalization tank to prevent surges in effluent discharges.
- *Chemical and Physical Treatment:* Wastewater treatment using both chemical and physical processes. For example, screening, sedimentation, and filtration are “physical” means of treatment; coagulation and precipitation are “chemical.”
- *Ion Exchange:* Use of an ion exchange resins such as zeolites to remove ammonia.

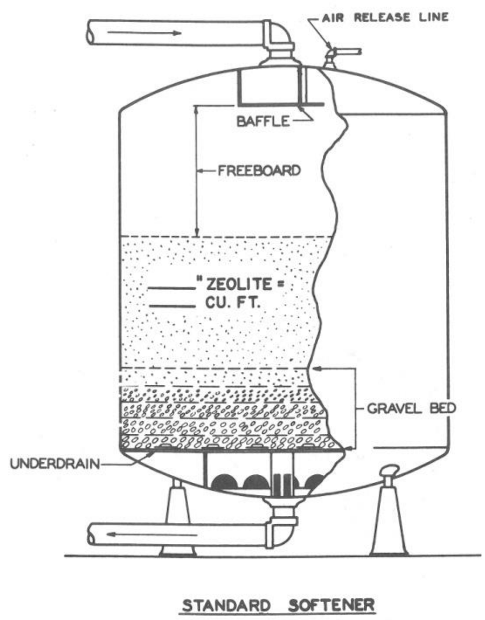


Figure 26 (Courtesy of Minnesota Rural Water Association)

- *Granular Media Filtration:* Use of filter media such as sand, anthracite, or gravel, for the separation of solids in the wastewater.
- *Membrane Filtration:* Use of membranes such as nanofilters and reverse osmosis, for the treatment of wastewater.

RO Unit

Figure 27 (Courtesy of Degremont Technologies)

- *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.
- *Electrodialysis Reversal (EDR):* Similar to ED but the polarity is reversed periodically to move ions in the opposite direction.

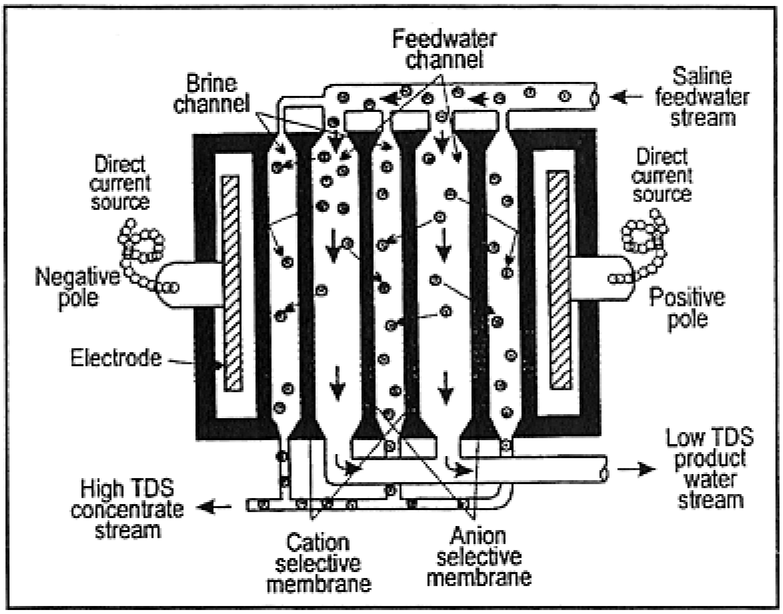


Figure 28 (Courtesy of United Nations Environment Programme)

- *Biological Nutrient removal (BNR):* The process by which total nitrogen and total phosphate are removed from wastewater through the use of microorganisms.
- *Nitrification:* Oxidation of ammonia to nitrite and nitrate.
  - *Extended Aeration:* Nitrification using the extended aeration process
- *Chemical Precipitation of Phosphorus:* Typically, lime is used to precipitate phosphorus. This requires lime feeding systems, mixing and flocculation areas, chemical clarification for sedimentation, and the proper pumps and piping for removal of lime-phosphorus sludge.
- *pH Adjustment:* Addition of chemicals to adjust the pH of the wastewater.
- *Activated Carbon Columns or Beds:* The use of activated carbon as a media to remove organic constituents from wastewater through adsorption.

In-plant Odor Control

- *Biofilter:* Use of naturally occurring microorganisms to treat air containing such odorous substances as hydrogen sulfide, reduced sulfur compounds, and volatile organic compounds (VOCs). Microorganisms reside on the surface of the biofilter media and only require irrigation water and small quantities of nutrient (for some applications). Microorganisms consume these odorous contaminants for energy and, in the process, cleanse the air. Media can be sea shells, perlite, mineral based,
- *Adsorption w/ Activated Carbon or another Adsorbent:* Use of an air collection system that includes activated carbon beds to adsorb the foul odors.
- *Wet Scrubber:* Provides contact between odorous air, water, and chemicals to provide oxidation or entrainment of the odorous compounds. The odorous compounds are absorbed into the scrubber

liquid, where they are oxidized and/or removed from the scrubber as an overflow or blowdown stream.

- *Thermal Deactivation w/ Catalytic Process:* Combustion of odorous gases. The optimal temperature of combustion is greater than 1,500°F; however, with a use of a catalyst this temperature can be reduced.
- *Odor-Reducing Sprays:* The use of a masking agent or chemical distributed by sprayers to impart a pleasant odor when mixed with the odorous compound.

Sludge Thickening & Dewatering

- *Sludge Decant Tank:* Similar to secondary clarifiers, sludge decant tanks allow collected settled material to be removed by scrapers or flights.
- *Gravity Thickener Basin:* Usually a circular basin, resembling a circular clarifier, where solids that are heavier than water settle to the bottom and then are compacted by the weight of other solids settling on top of it. The resulting compacted sludge is raked to the sludge hopper where it is pumped by a pump to an area where they can be disposed of. The effluent will overflow the weir and return back to the treatment train.

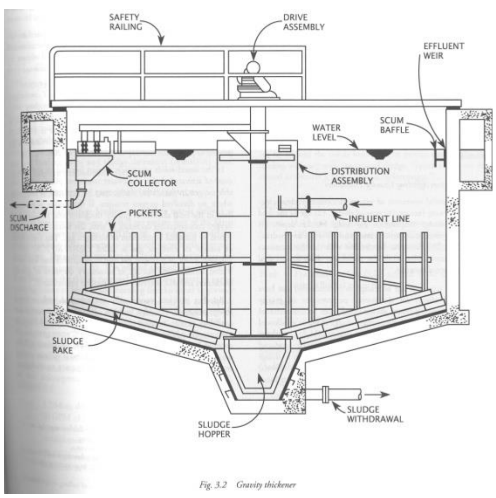


Figure 29 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

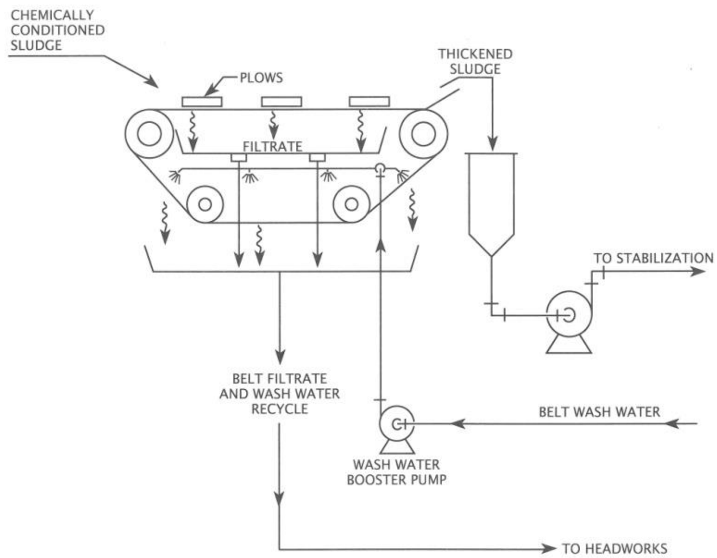


Fig. 3.12 Gravity belt thickener

Figure 30 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

- *Gravity Belt Thickener:* Chemically conditioned sludge (usually treated with polymer) is applied to the belt of the thickener where the free water from the belt drains through small holes located in the belt into a trough where it is collected and reintroduced into the treatment train. The thickened sludge is then removed from the belt to be transferred to the next sludge treatment process, usually stabilization.

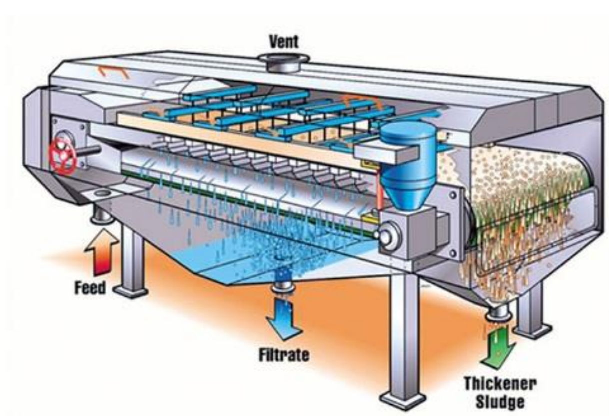


Figure 31 (Courtesy of BDP Industries)

- *Screw Press:* The screw press contains a conical shaped wire basket. Preconditioned sludge enters one end of the screw press. As the sludge travels through the press, free water drains through the wire basket. The sludge is conveyed through the conical basket by a slowly turning screw. As the surface area decreases the pressure exerted on the sludge increases thereby squeezing more water out of the sludge. The dewatered sludge is discarded and the free water is reintroduced into the treatment train.

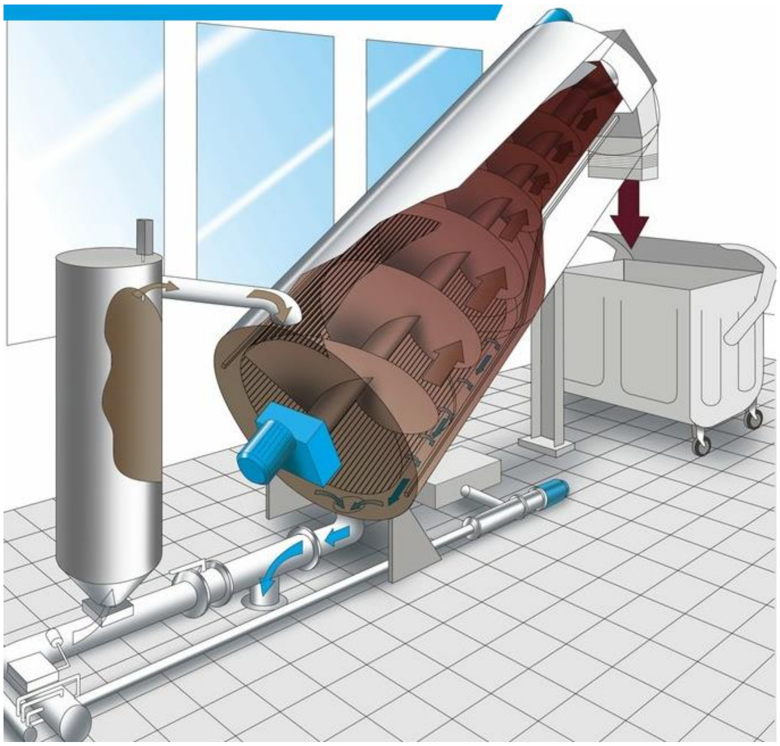


Figure 32 (Courtesy of Huber Technology)

- *Centrifuge:* Thickening of sludge by use of centrifugal forces. Sludge is fed into a rotating bowl at a constant feed rate. Centrifugal forces fling the sludge to the walls of the bowl where it is compacted and the water is extracted. The water and some fine particles exit the centrifuge via an effluent line. The three common types of centrifuges used today are (1) disc nozzle centrifuge, (2) basket centrifuge, and (3) scroll centrifuge.

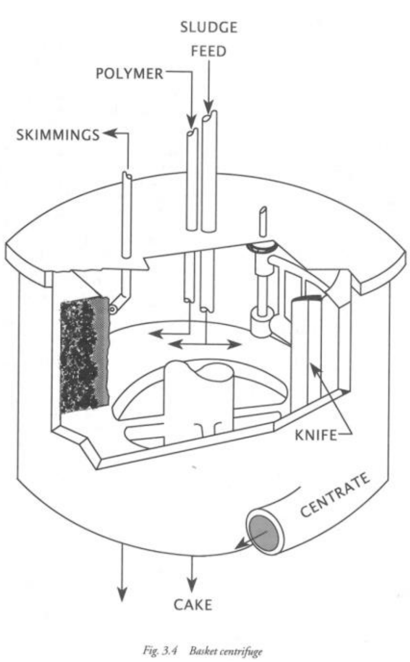


Figure 33 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

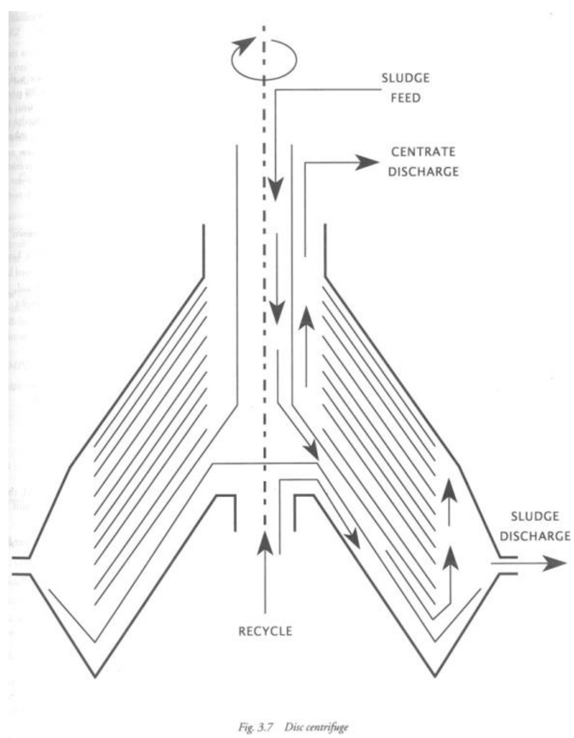


Figure 34 Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

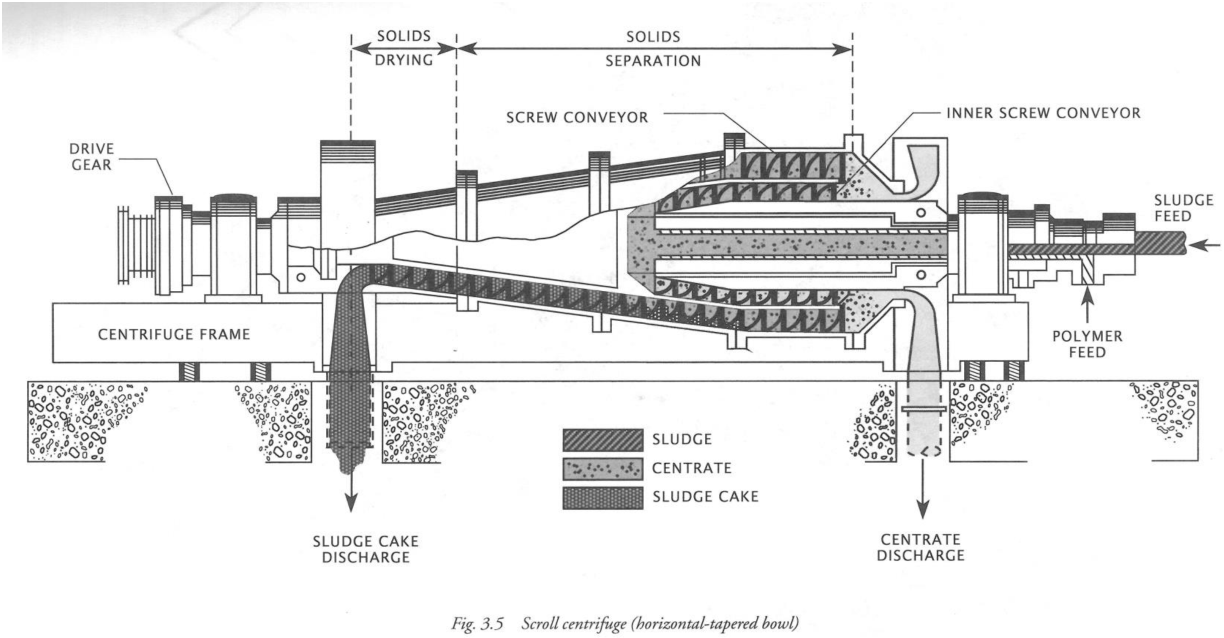


Figure 35 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

- *Belt Filter Press:* Preconditioned sludge first travels an area similar to the gravity belt thickener where free water is drained through perforations in the belt into a trough. Then, the sludge enters a zone where it is trapped between two endless belts where pressure is applied and water is forced from the sludge.

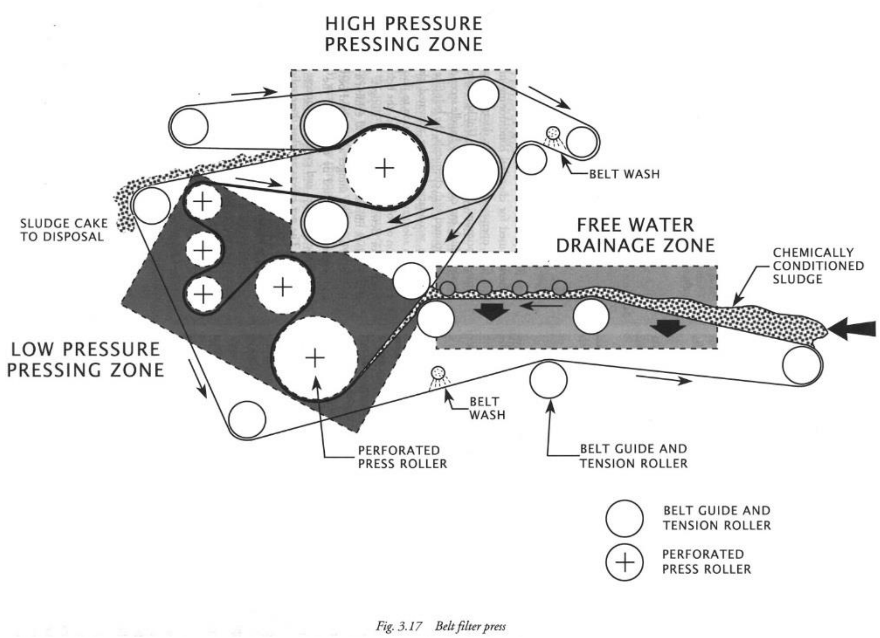


Figure 36 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

- *Vacuum Filter:* Preconditioned sludge is fed into a vat containing a cylindrical drum covered with a filter media. The drum is partially submerged in the vat. The drum is divided into a pick up zone which has the highest vacuum, a cake drying zone where the vacuum is decreased slightly where water is drawn from the sludge mat and discharged, and a discharge zone where the vacuum is near zero and the sludge is separated from the drum.

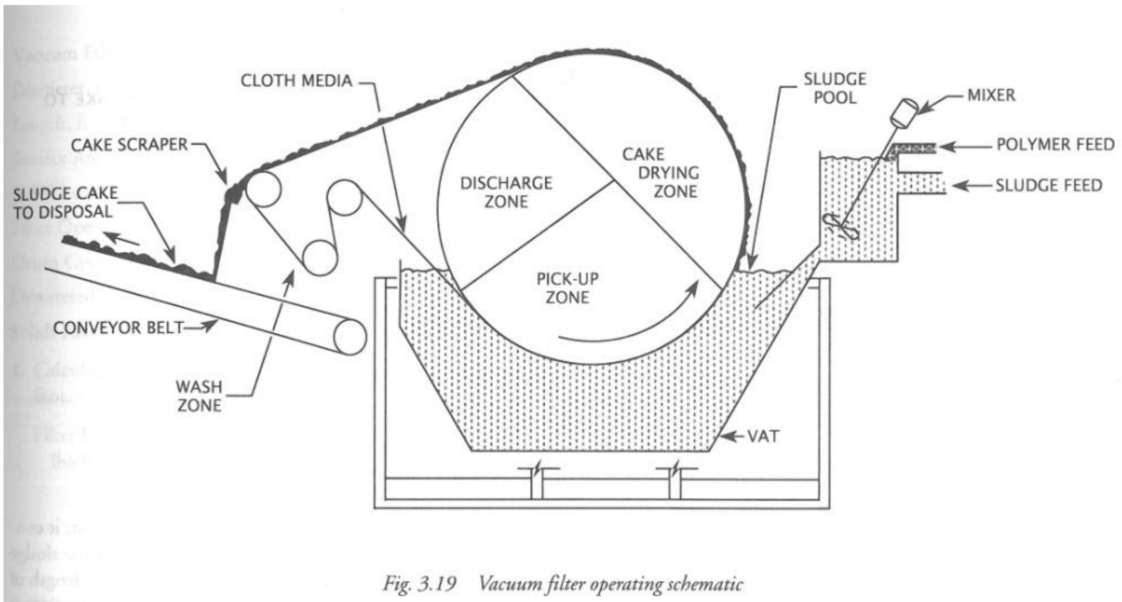


Figure 37 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

- *Plate-and-Frame Press:* The press is comprised of vertical plates with filter cloth mounted on each plate that are held rigidly in a frame and pressed together. The press is operated in batch mode. Sludge is fed into the press through feed holes spanning the length of the press. Water passes through the filter cloth, collected in drain ports at the bottom of each press chamber, and discharged. The solids remain

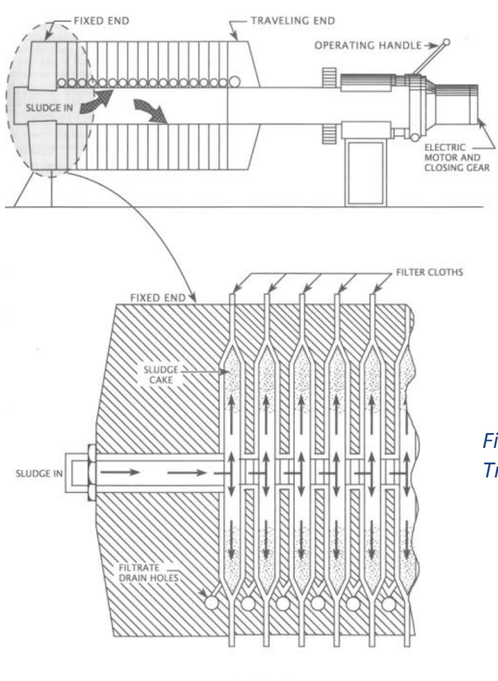


Figure 38 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

and are allowed to build up until the space between the filters fills completely with solids. The solids build up resistance to flow increases thereby compacting the solids. When the amount of flow nears zero the feed is shut off and the plates are separated. As the plates are separated, the cake will fall out of the press into a hopper or conveyor.

- *Sludge Bagger:* Typically used for small WWT plants that do not produce high volumes of sludge. Sludge is pumped into disposable polypropylene bags that are made of porous material. The sludge is dewatered via combination of gravity and pressurization. Once the bags are full they can be stacked to further dewater the sludge.

Figure 38 (Courtesy of MISCO water)

- *Drying Beds:* Sludge can be dried by evaporation using sand drying beds or surfaced sludge drying beds.

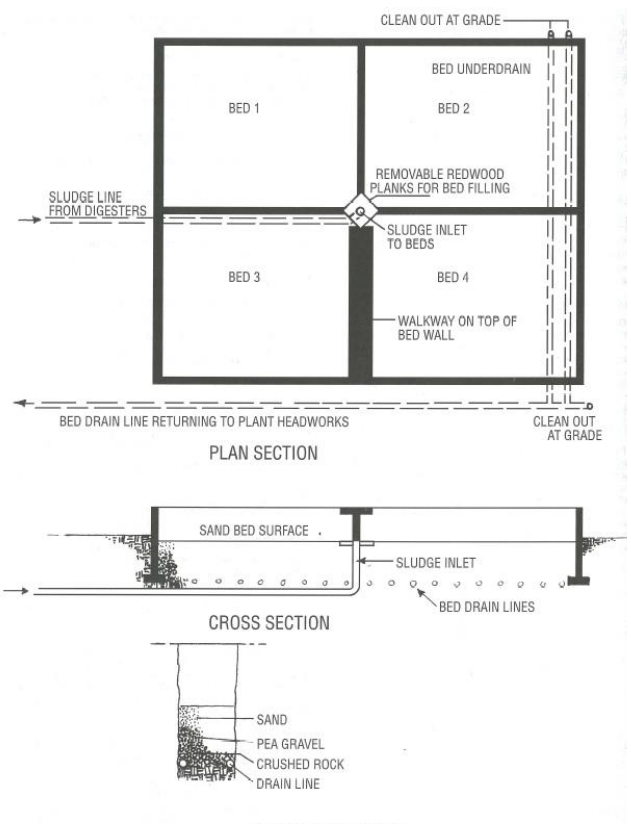


Figure 40 (Courtesy of CSU Operation of Wastewater Treatment Plants, Vol. II, 7th Ed.)

Sludge Stabilization and Conditioning

- *Anaerobic Digestion:* A multistage biochemical process that stabilizes sludge in an anaerobic environment resulting in the production of methane and carbon dioxide gases. This process can occur heated in which the sludge is fermented in tanks at 131° F or unheated at around 98° F.

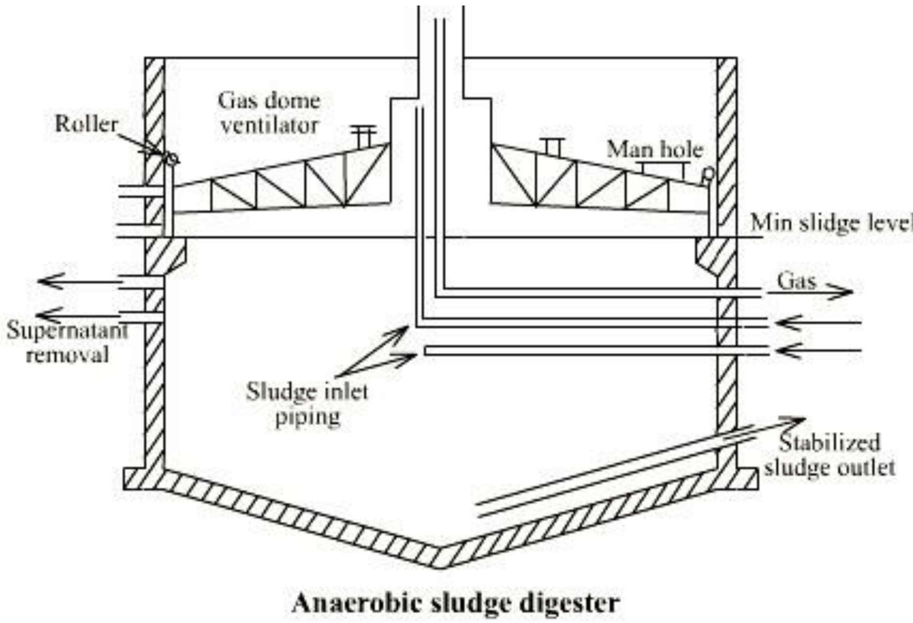


Figure 41 (National Programme on Technology Enhanced Learning)

- *Aerobic Digestion:* A biological treatment process that uses aeration to stabilizes sludge. Similar to the principle of extended aeration ion the activated sludge process.

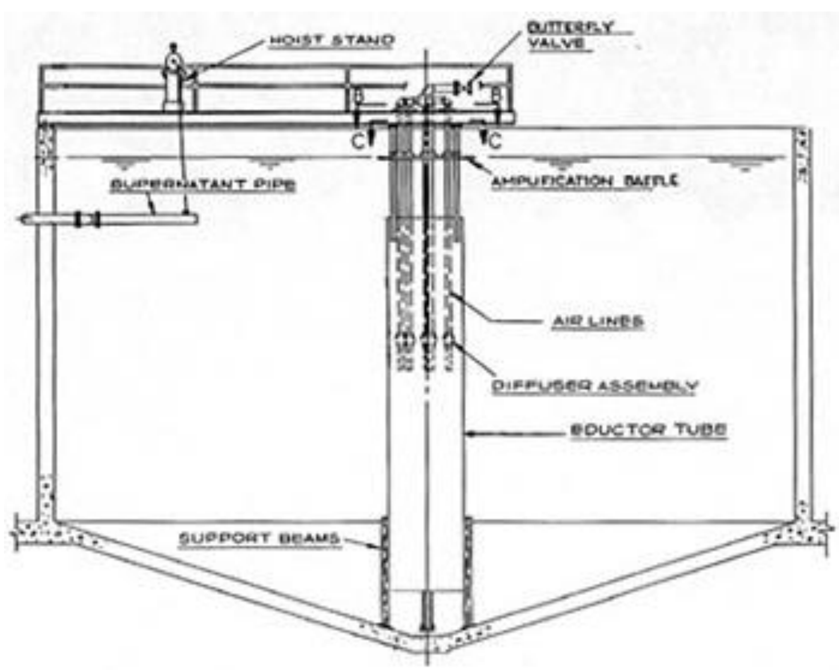


Figure 42 (Courtesy of WriteOpinions.com)

- *Wet Oxidation:* The oxidation of soluble or suspended components in wastewater using oxygen as the oxidizing agent. The oxidation reactions occur at temperatures of 275° F to 608° F and pressures from 150 to 3200 psig. The wet air oxidation (WAO) process can pretreat difficult wastewater streams, making them amenable for discharge to a conventional biological treatment plant for polishing.

Figure 43 (Courtesy of Siemens Inc.)

- *Chemical Stabilization with Lime:* A batch or continuous process where lime is added to the sludge and then mixed in a tank for 30 minutes at a pH of 11.5 to 12. The process of lime stabilization produces unfavorable conditions which destroys pathogenic and nonpathogenic bacteria.
- *In-vessel Composting:* The decomposition of organic matter combined with a bulking agent in an enclosed reactor.

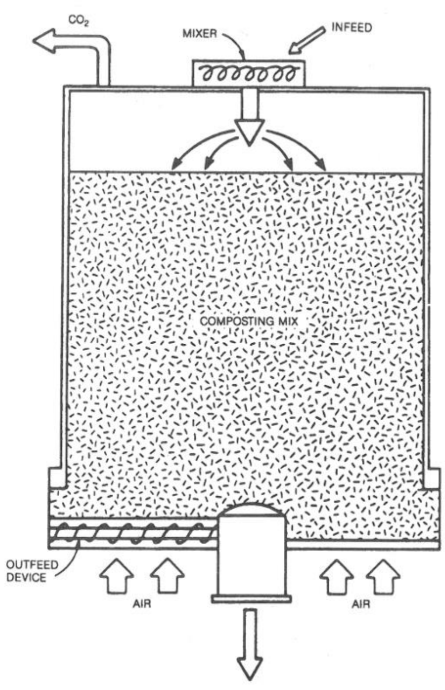


FIGURE 32.4 Silo type in-vessel composting system.

Figure 44 (Courtesy of WEF Operation of Municipal Wastewater Treatment Plants Vol. III Solids Processes 6th Ed.)

- *Static Pile Composting:* The decomposition of organic matter combined with a bulking agent using a fixed pile. Typically, a perforated aeration header is located in the base of the pile to provide air distribution for aerobic decomposition.

Figure 45 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)

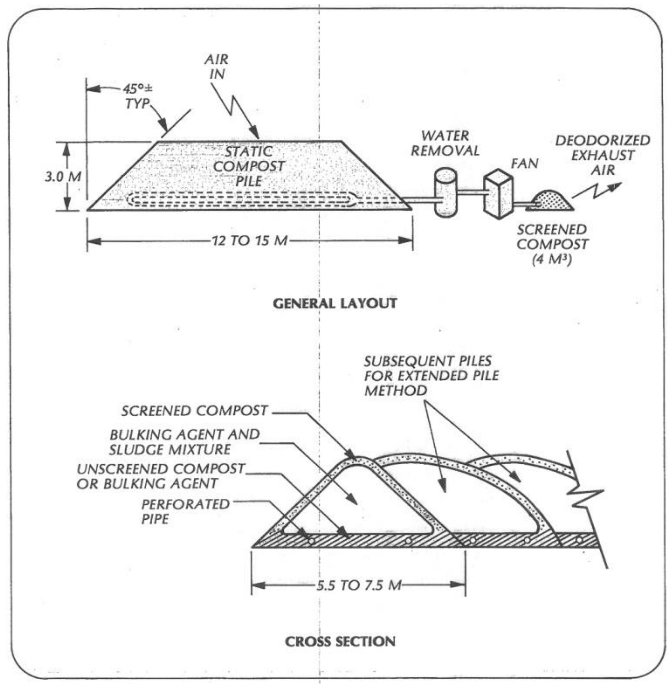


Figure 1. Typical Static Compost Pile for 40 Cubic Meters of Dewatered Sludge

Solids Disposal

- *Incineration:* The conversion of dewatered wastewater solids by combustion to ash, carbon dioxide, and ash.

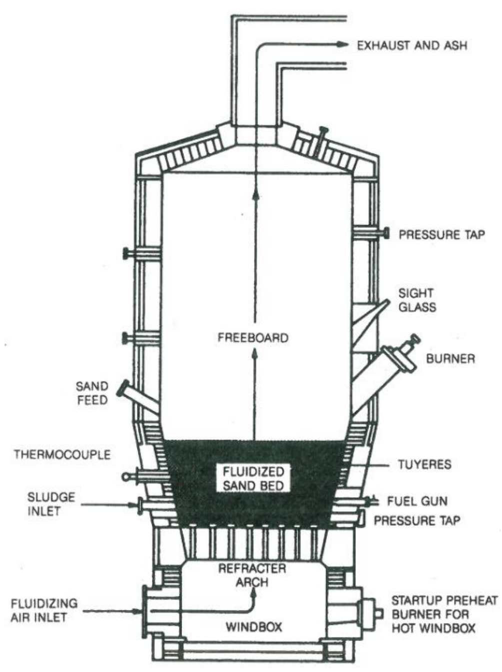


Figure 46 (Courtesy of WEF Operation of Municipal Wastewater Treatment Plants Vol. III Solids Processes 6th Ed.)

FIGURE 32.12 Fluidized-bed incinerator schematic.

- *Land Application:* Disposal of sludge on agricultural or nonagricultural lands.
- *Sludge Lagoon:* The use of dedicated facultative lagoons to dispose of sludge.

- *Off-site Disposal:* The sludge is taken to an off-site location for disposal.

Disinfection

- *Chlorination:* An oxidation process that is initiated through the addition of chlorine. In chlorination, chlorine oxidizes microbiological material, organic compounds, and inorganic compounds.
    - *Powered or liquid hypochlorites.*
        - Chlorination using solutions of calcium hypochlorite ($Ca(OCl)_2$) or sodium hypochlorite (NaOCl).

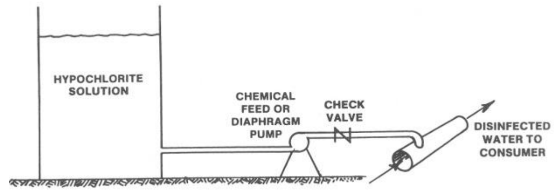
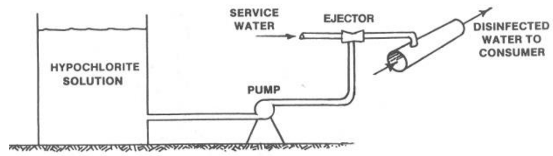


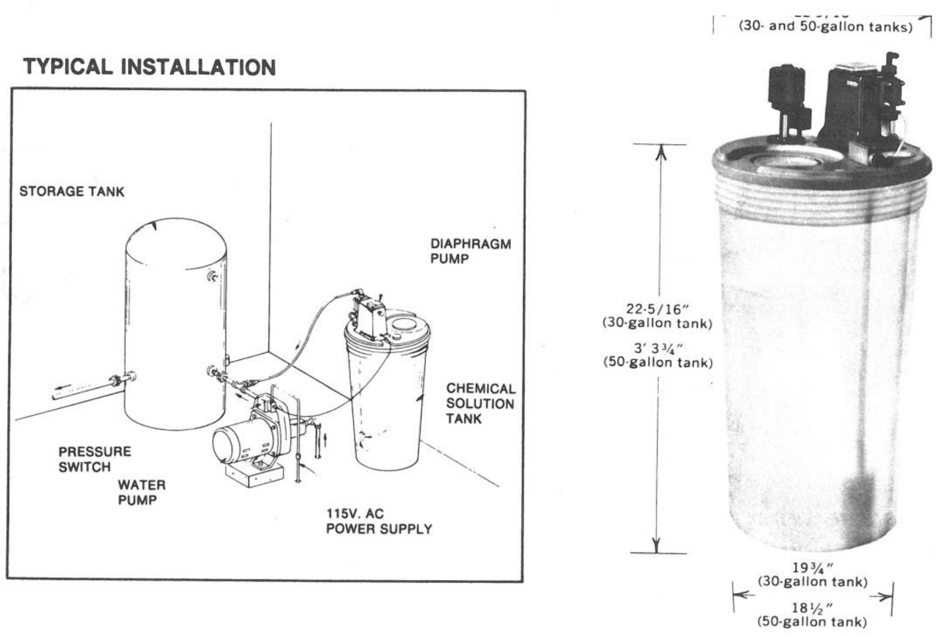
Fig. 7.10 Hypochlorinator direct pumping system



NOTE: Pump is chemical feed or diaphragm pump.

Fig. 7.11 Hypochlorinator injector feed system

Figure 47 (Courtesy of CSU Water Treatment Plant Operation Vol. I, 6th Ed.)



Pump-tank system for chemical mixing and metering. Cover supports pump, impeller-type mixer, and liquid-level switch.

Fig. 7.7 Typical hypochlorinator installation

(Permission of Wallace & Tiernan Division, Pennwalt Corporation)

Figure 48 (Courtesy of Wallace & Tiernan Division, Pennwalt Corporation)

- *On-site generation of hypochlorites:* Hypochlorites can be generated on-site by combining salt, water and electricity.
  $NaCl + H_2O \rightarrow NaOCl + H_2$

Figure 49 (Courtesy of ClorTec On-Site Sodium Hypochlorite Generating Systems)

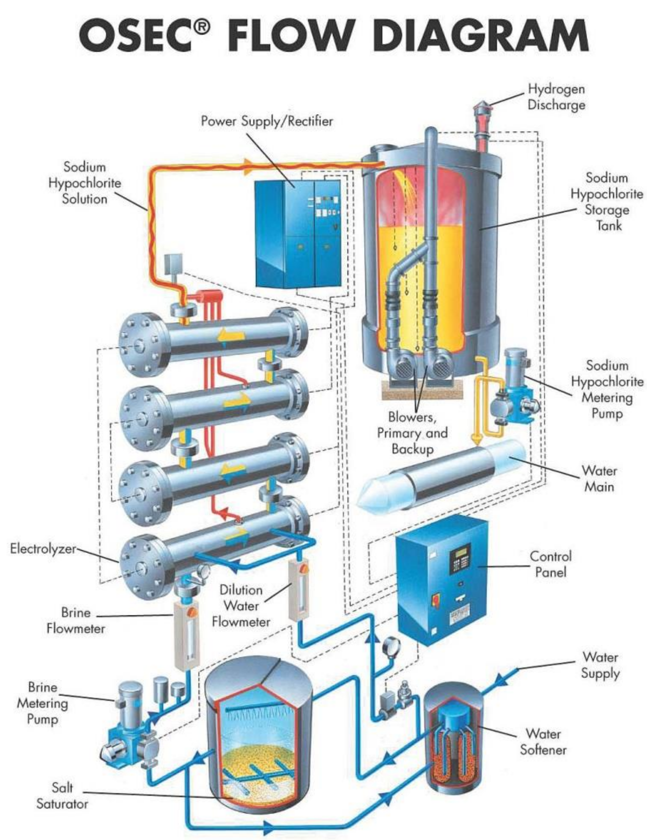
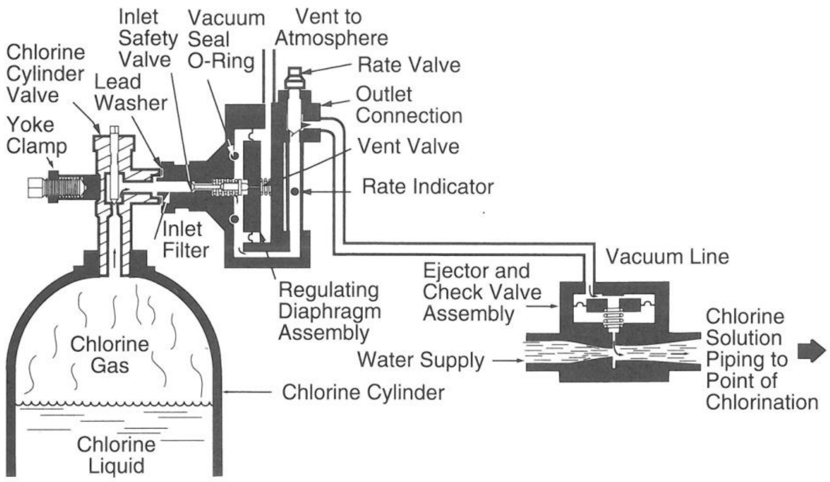


Figure 50 (Courtesy of Siemens Inc.)

- *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 ($HOCl \Leftrightarrow OCl^- + H^+$).*

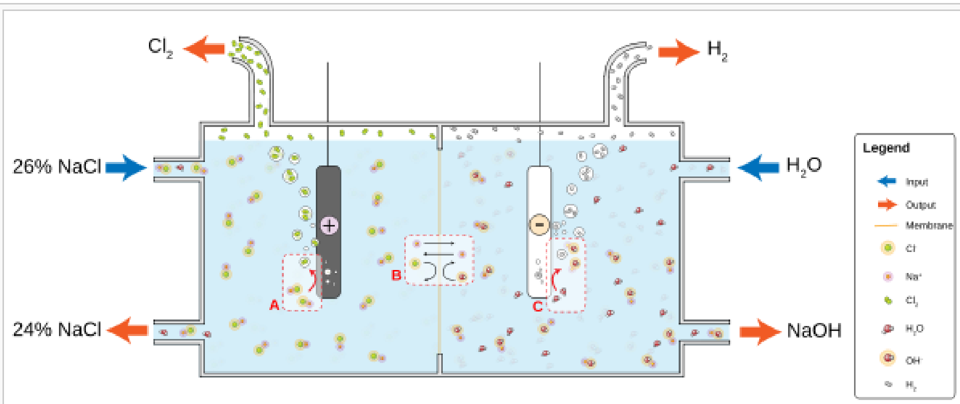


Courtesy of Severn Trent Services

FIGURE 7–27 Schematic of direct-mounted gas chlorinator

Figure 51 (Courtesy of Severn Trent Services)

- *Chloro-Alkali on-site generation:* The process of producing chlorine gas or sodium hypochlorites and sodium hydroxide by electrolysis of a salt brine solution.



Basic membrane cell used in the electrolysis of brine. At the anode (**A**), chloride (Cl^-) is oxidized to chlorine. The ion-selective membrane (**B**) allows the counterion Na+ to freely flow across, but prevents anions such as hydroxide (OH^-) and chloride from diffusing across. At the cathode (**C**), water is reduced to hydroxide and hydrogen gas. The net process is the electrolysis of an aqueous solution of NaCl into industrially useful products sodium hydroxide (NaOH) and chlorine gas.

Figure 52 (Courtesy of Wikipedia)

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

Figure 53 (Courtesy of Global Treat Inc.)

Figure 54 (Courtesy of Clean Pool and Spa)

- *UV Light:* The use of a UV light system to conduction disinfection.

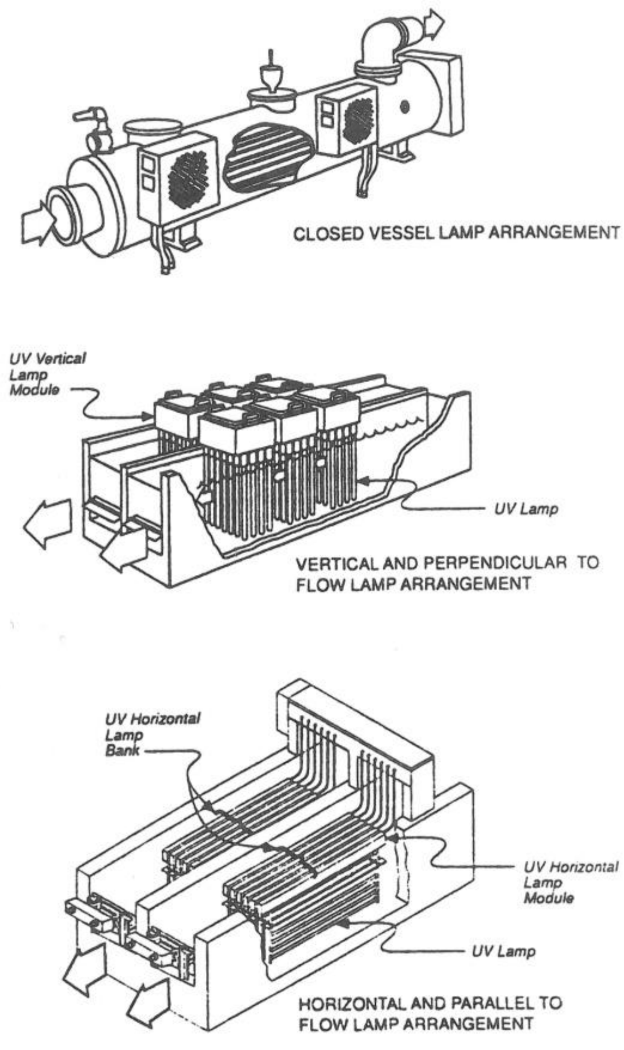
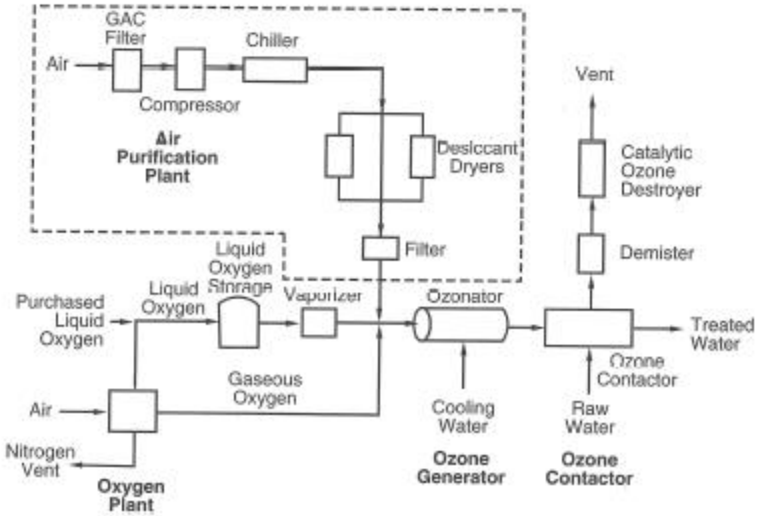


Fig. A-10.2 Typical UV lamp configurations
(Source: "Ultraviolet Disinfection," by CH2M Hill, reproduced with permission of CH2M Hill)

Figure 55 (Courtesy of CH2M Hill)

- *Ozonation:* The process of applying ozone, a very strong oxidant, to disinfect the wastewater. Since ozone is very unstable it must be produced on-site. The source of oxygen to produce ozone can be pure oxygen, oxygen enriched air, or air that has been dried.



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

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

Figure 56 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

Figure 57 (Courtesy of Spartan Environmental Technologies)

- *Dechlorination:* The removal of chlorine from wastewater effluent. Chlorine needs to be removed because it is toxic to fish and other aquatic life. Typically, sulfur dioxide is used for dechlorination and can be introduced to the wastewater effluent in gas, liquid, powered, or tablet form.

Effluent Discharge

- *Plant Pumping of Effluent:* The wastewater effluent is pumped from the treatment plant to its final destination.
- *Effluent Aeration:* The wastewater effluent is aerated prior to discharge.

Figure Index

Figure 1 (Courtesy of Sustainable IIT Delhi)
Figure 2 (Courtesy of www.infobarscreens.com)
Figure 8 (Courtesy of China Chemnet)
Figure 4 (Courtesy of schreiberwater.com/FineScreen.shtml)
Figure 5 (Courtesy of water.me.vccs.edu)
Figure 6 (Courtesy of CSU Operation of Wastewater Treatment Plants, Vol. 1; 7th ed.)
Figure 7 (Courtesy of sispaltd.com)
Figure 8 (Courtesy of Schloss Engineered Equipment, INC., CO.)
Figure 9 (Courtesy of undermontreal.com/montreal-wastewater-treatment-plant/)
Figure 10 (Courtesy of techalive.mtu.edu/meec/module21/CSOs.htm)
Figure 11 (Courtesy of commons.wikimedia.org/wiki/File:Emscherbrunnen.jpg)
Figure 12 (Courtesy of Mbeychok)
Figure 13 (Courtesy of web.deu.edu.tr/atiksu/ana52/biofilm2.html)
Figure 14 (Courtesy of City of Portland)
Figure 15 (Courtesy of Hitachi Oxidation Ditch System)
Figure 16 (Courtesy of wis-ni.com)
Figure 17 (Courtesy of Ecosafe Solutions)
Figure 18 (Courtesy of Union Carbide Corporation)
Figure 19 (Courtesy of University of Florida TREEO Comtec)
Figure 20 (Courtesy of Xylem, Inc.)
Figure 21 (Courtesy of WEF Operator of Municipal Wastewater Treatment Plants Vol. II Sixth Ed.)
Figure 22 (Courtesy of Skaneateles Wastewater Treatment Plant)
Figure 23 (Courtesy of Fixed Film Forum)
Figure 24 (Courtesy of NPS Photo: Wind Cave National Park)
Figure 25 (Courtesy of University of British Columbia)
Figure 26 (Courtesy of Minnesota Rural Water Association)
Figure 27 (Courtesy of Degremont Technologies)
Figure 28 Courtesy of United Nations Environment Programme)
Figure 29 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 30 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 31 (Courtesy of BDP Industries)
Figure 32 (Courtesy of Huber Technology)
Figure 33 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 34 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 35 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 36 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 37 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 38 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 39 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 39 (Courtesy of MISCO water)
Figure 40 (Courtesy of CSU Operation of Wastewater Treatment Plants, Vol. II, 7th Ed.)
Figure 41 (National Programme on Technology Enhanced Learning)
Figure 42 (Courtesy of WriteOpinions.com)
Figure 43 (Courtesy of Siemens Inc.)

Figure 44 (Courtesy of WEF Operation of Municipal Wastewater Treatment Plants Vol. III Solids Processes 6th Ed.)
Figure 45 (Courtesy of CSU Advanced Waste Treatment, 5th Ed.)
Figure 46 (Courtesy of WEF Operation of Municipal Wastewater Treatment Plants Vol. III Solids Processes 6th Ed.)
Figure 47 (Courtesy of CSU Water Treatment Plant Operation Vol. I, 6th Ed.)
Figure 48 (Courtesy of Wallace & Tiernan Division, Pennwalt Corporation)
Figure 49 (Courtesy of ClorTec On-Site Sodium Hypochlorite Generating Systems)
Figure 50 (Courtesy of Siemens Inc.)
Figure 51 (Courtesy of Severn Trent Services)
Figure 52 (Courtesy of Wikipedia)
Figure 53 (Courtesy of Global Treat Inc.)
Figure 54 (Courtesy of Clean Pool and Spa)
Figure 55 (Courtesy of CH2M Hill)
Figure 56 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)
Figure 57 (Courtesy of Spartan Environmental Technologies)

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

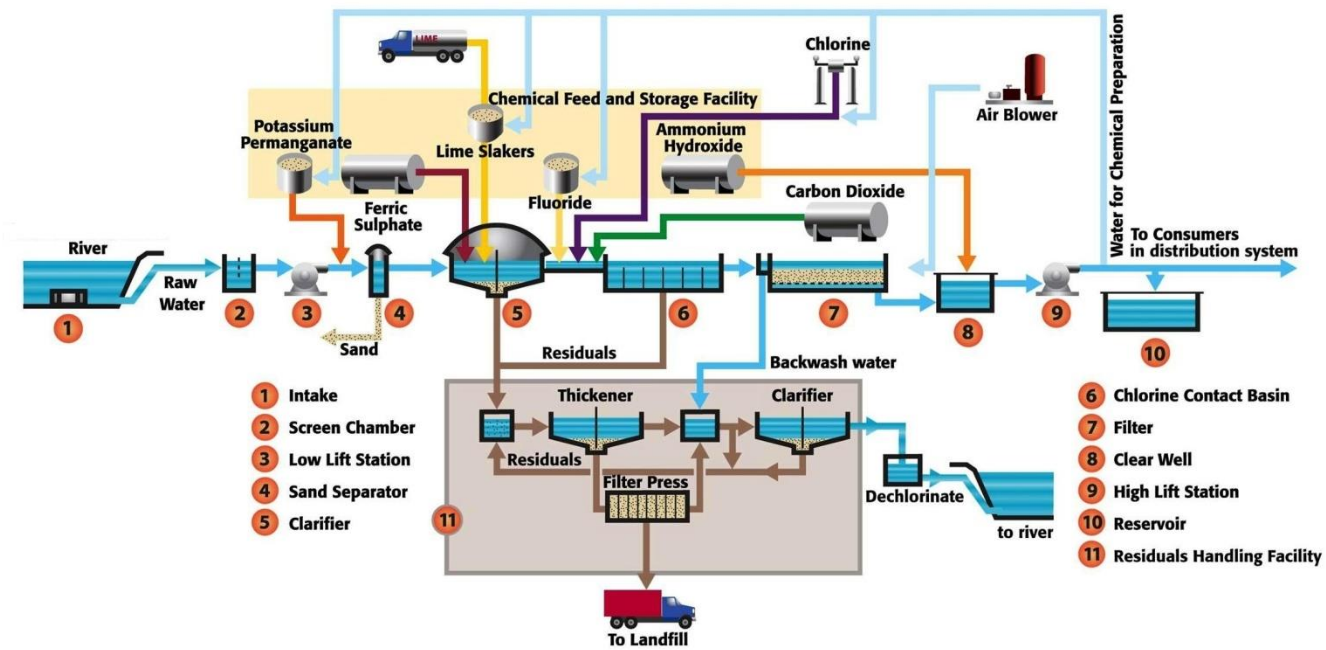


Figure 1 (Courtesy of Saskatoon, Canada 2012 Water Quality Report)

Pretreatment

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

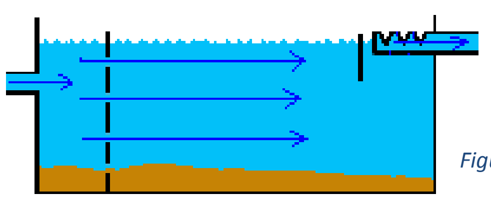


Figure 2 (Courtesy of Mountain Empire Community College Water/Wastewater Site)

- *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.

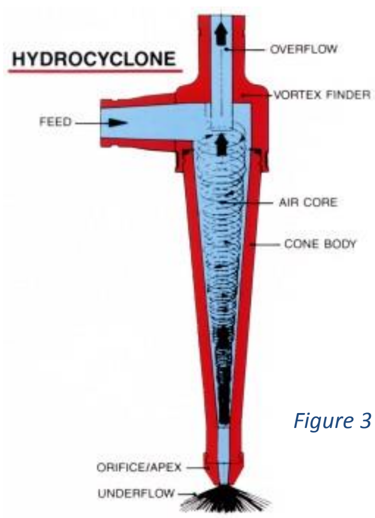


Figure 3 (Courtesy of Jiangxi Gandong Mining Equipment Machinery Manufacturer Factory)

- *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

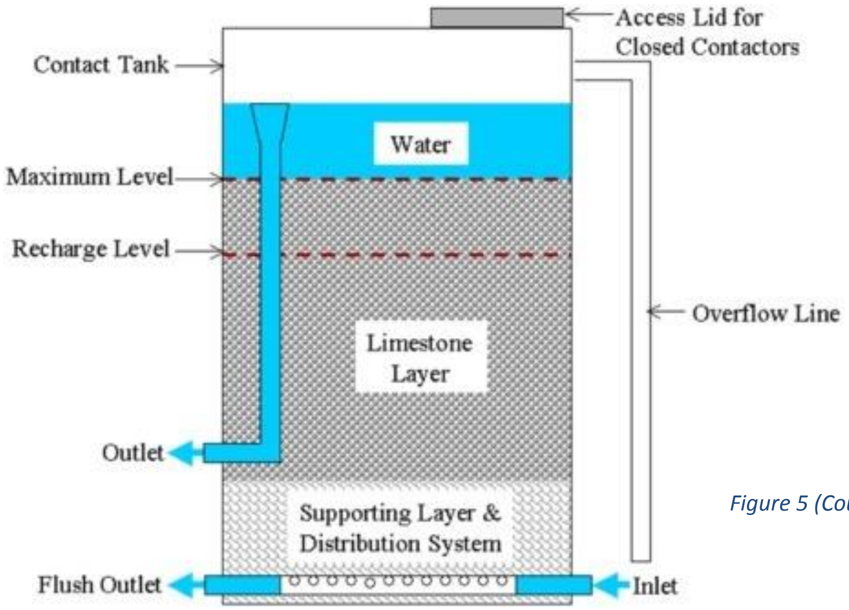


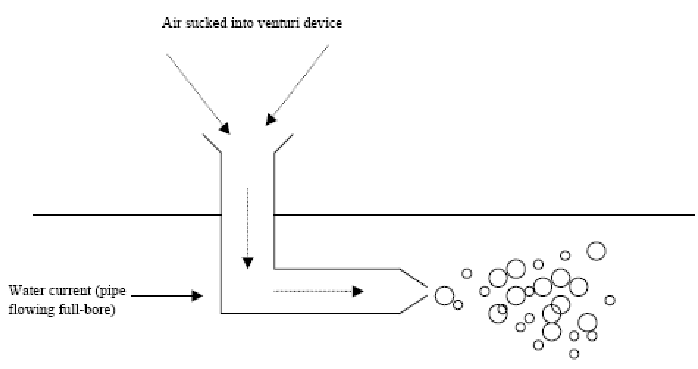
Figure 5 (Courtesy of Nikolay Voutchkov © 2011)

- *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:

  A. Surface aerator
  B. Submerged aerator
  C. Combination mechanical aerator
  D. Draft-tube surface aerator

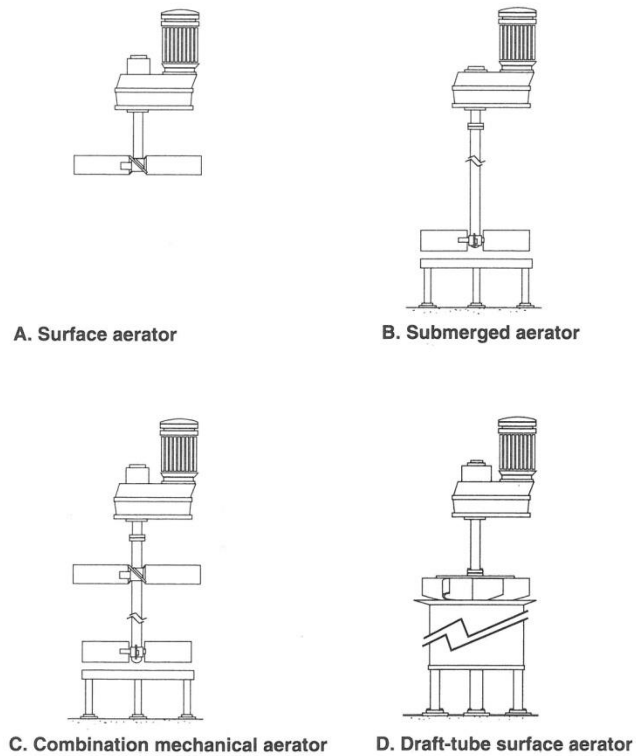


Figure 6 (Courtesy of Philadelphia Mixers Corporation)

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

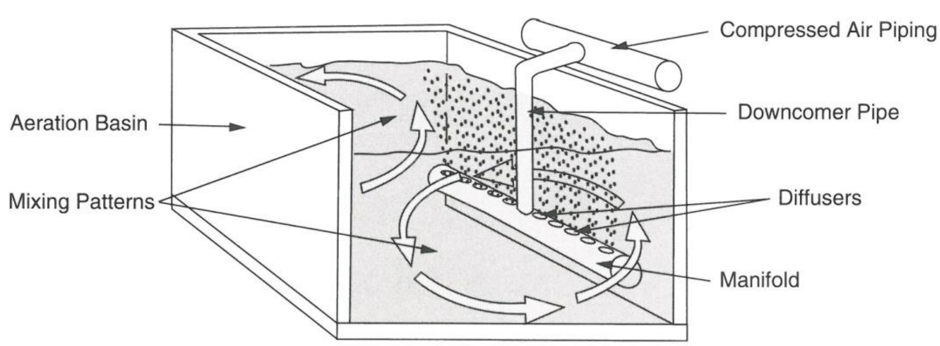


Figure 7 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- *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.

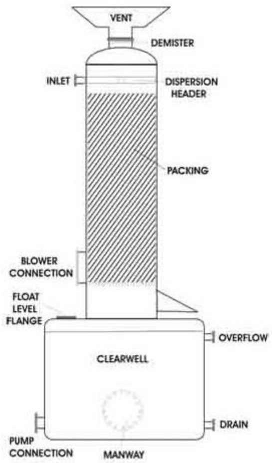


Figure 8 (Courtesy of Pure Aqua, Inc.)

- *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.

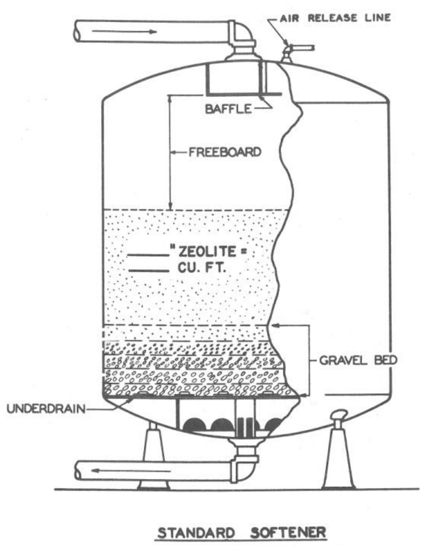


Figure 9 (Courtesy of Mountain Empire Community College Water/Wastewater Distance Learning)

- *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

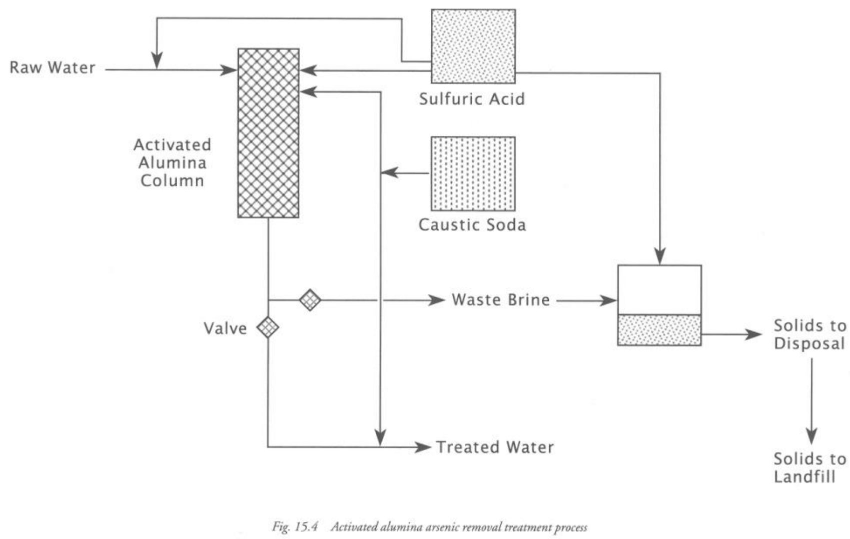


Figure 10 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

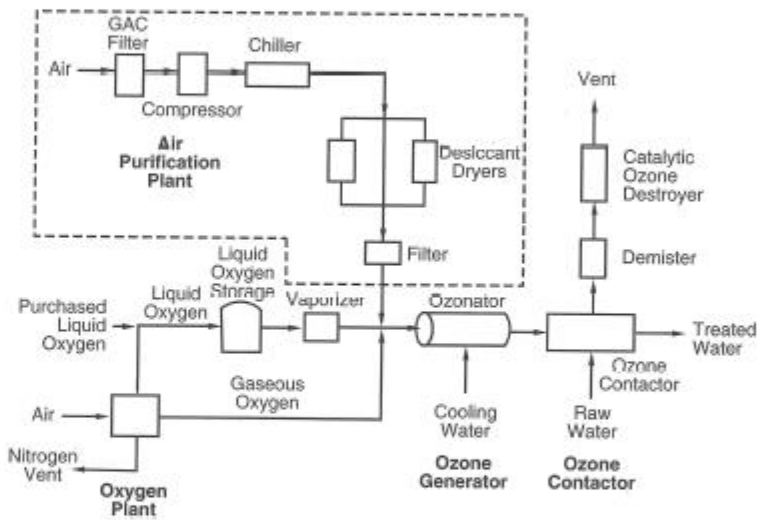
- *Activated carbon:* A form of particulate carbon (a crude form of graphite) with increased surface area to enhance adsorption of soluble contaminants.
    - *Activated carbon cartridge or bag filter:* A cartridge or bag filter containing activated carbon which is discarded after use.
    - *Powdered 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 (hyphochlorus 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:*

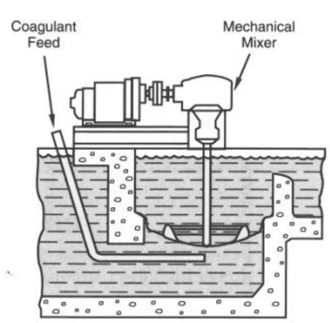


FIGURE 4–8 Mechanical mixing chamber—single-blade mixer

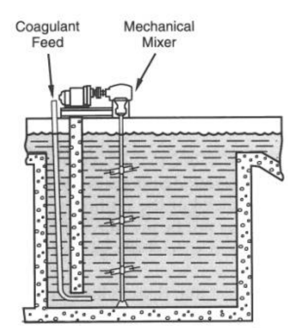


FIGURE 4–9 Mechanical mixing chamber—multiple-blade mixer

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

- *Injection mixer:*

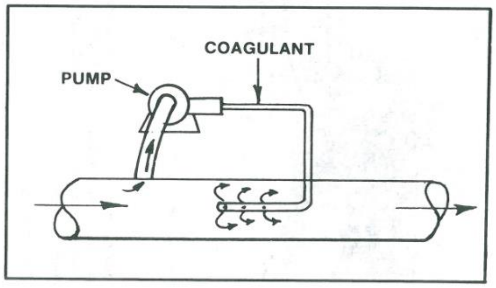


Figure 14 (Courtesy of CSU Water Treatment Plant Operation, Vo. I, Sixth Ed.)

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

- *In-line blender mixer:*

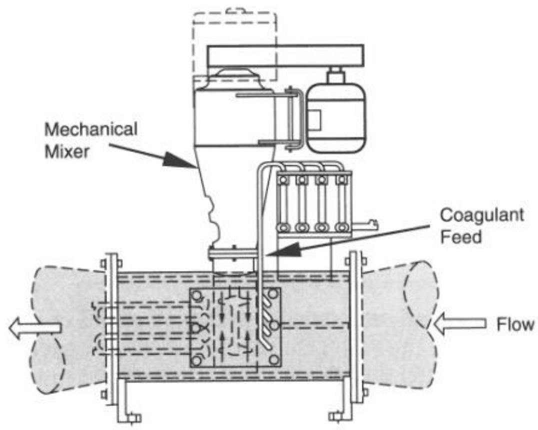
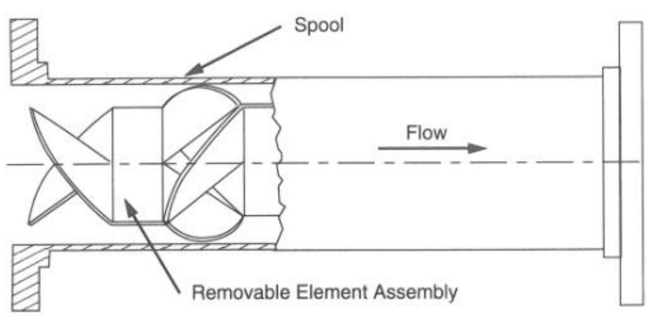


FIGURE 4–10 In-line mixer

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:*

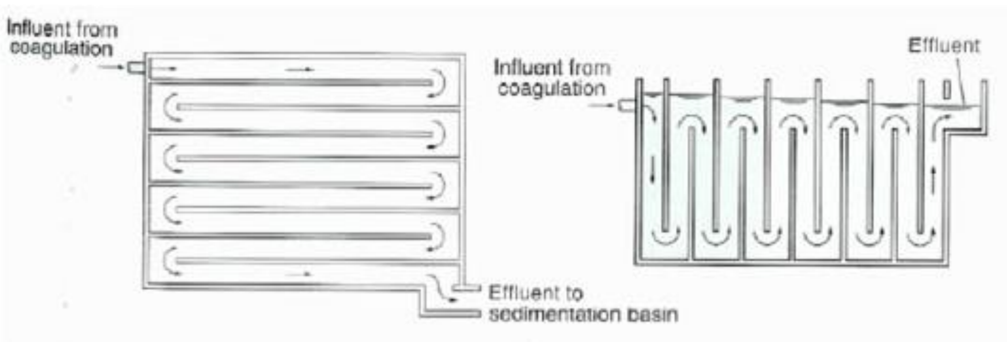
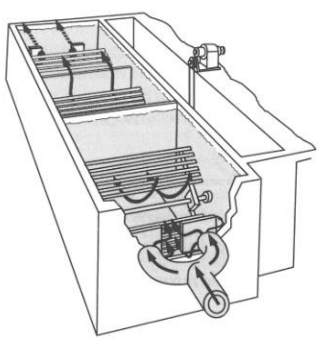


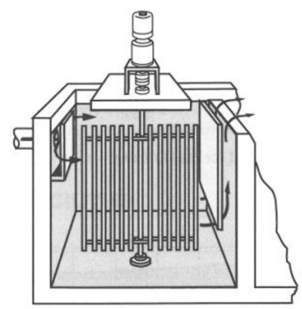
Figure 17 (Courtesy of Mountain Empire Community College Water/Wastewater Site)

- *Mechanical flocculator:*



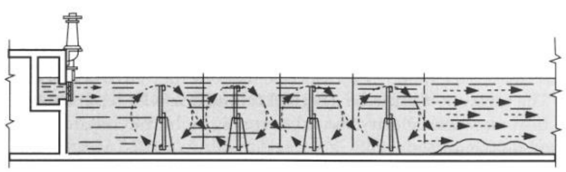
Courtesy of US Filter Envirex Products

A. Baffles and horizontal paddle-wheel floccu



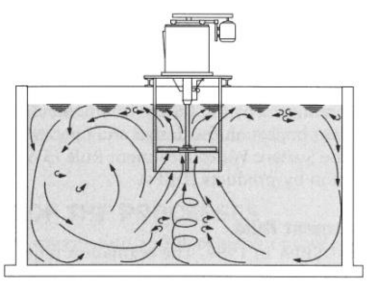
Courtesy of US Filter Envirex Products

B. Paddle-wheel flocculator, vertical type



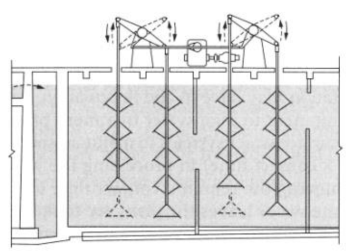
Courtesy of US Filter Envirex Products

C. Propeller flocculator



Courtesy of US Filter Envirex Products

D. Turbine flocculator



Courtesy of US Filter Envirex Products

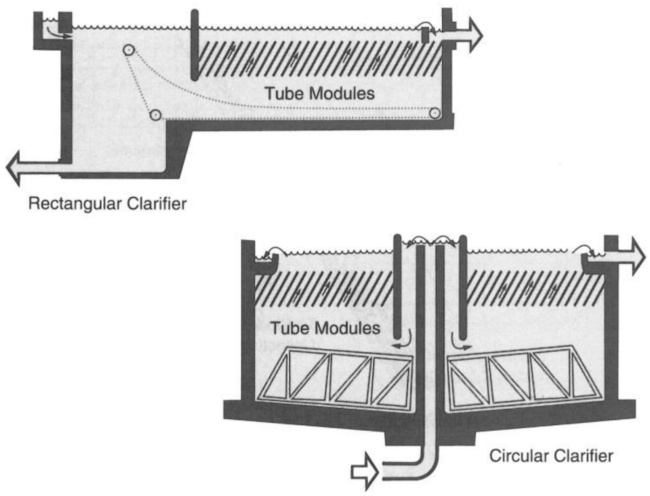
E. Walking-beam flocculator

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.

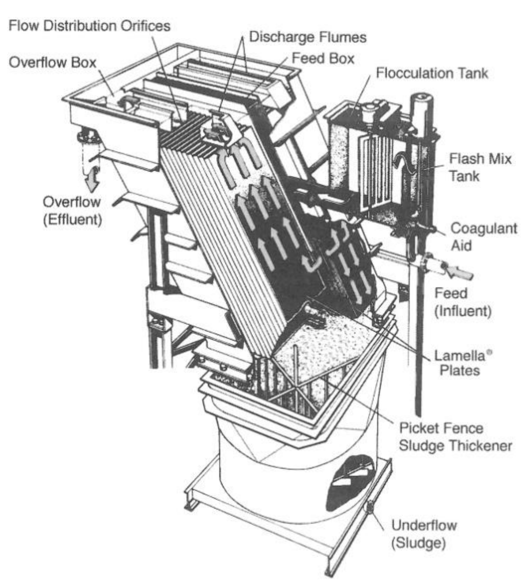


Courtesy of Wheelabrator Engineered Systems—Microfloc

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.

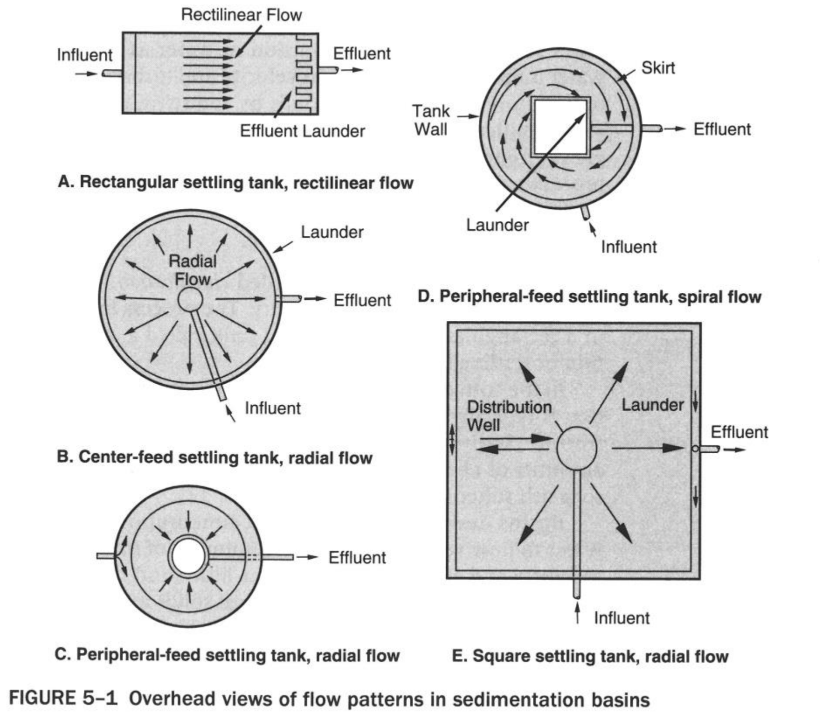


Figure 21 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- *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.

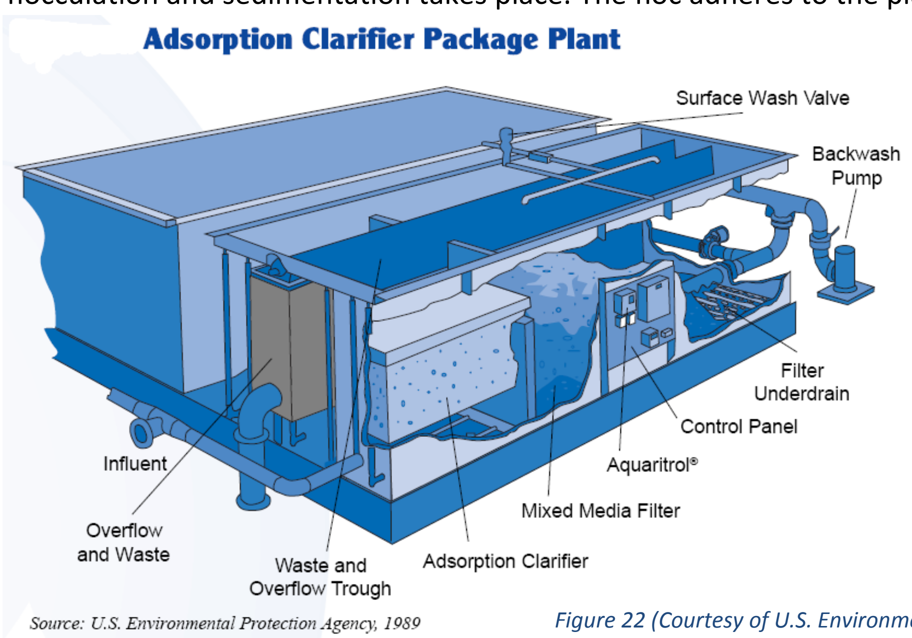
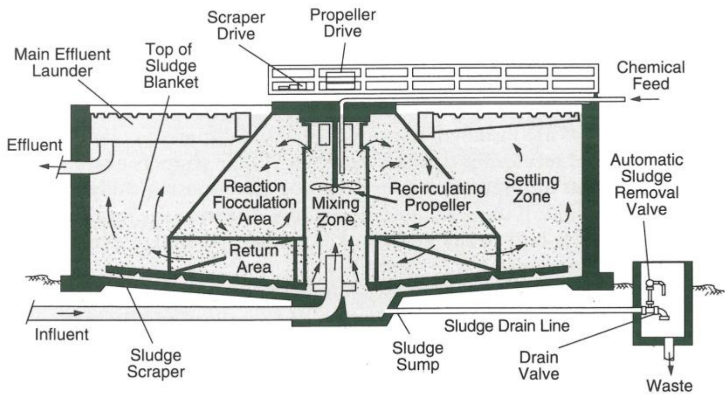


Figure 22 (Courtesy of U.S. Environmental Protection Agency; 1989)

- *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.

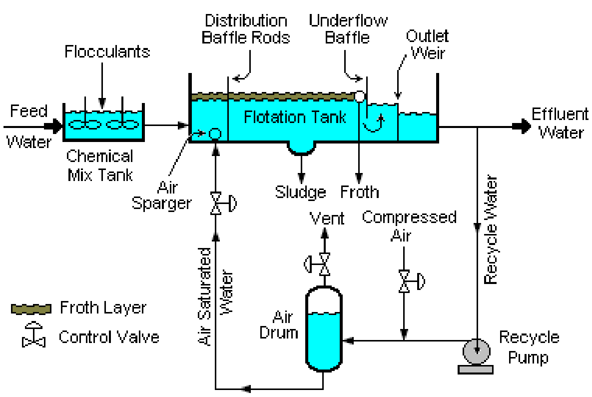


Figure 24 (Courtesy of Paper and Fibre Research Institute)

- *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.

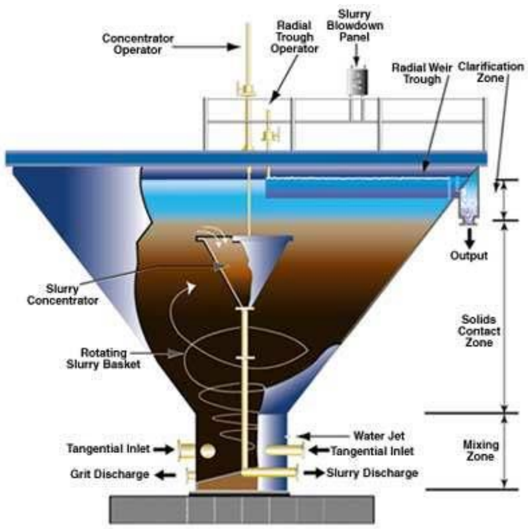


Figure 25 (Courtesy of CB&I)

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.

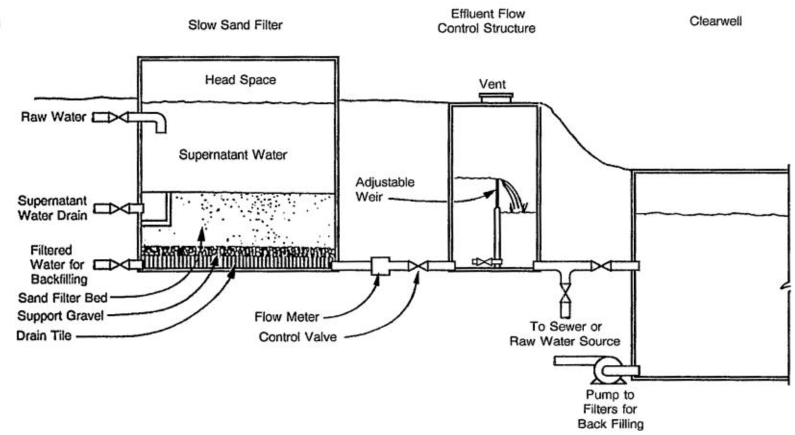


Figure 28 (Courtesy of Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities)

- *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.

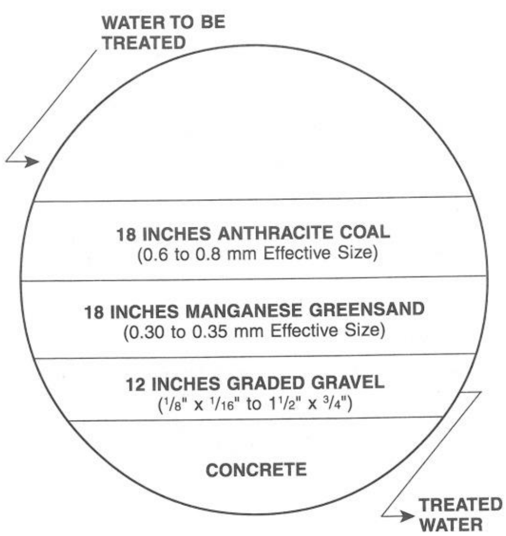


Fig. 12.4 Multi-media manganese greensand filter (horizontal)

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.

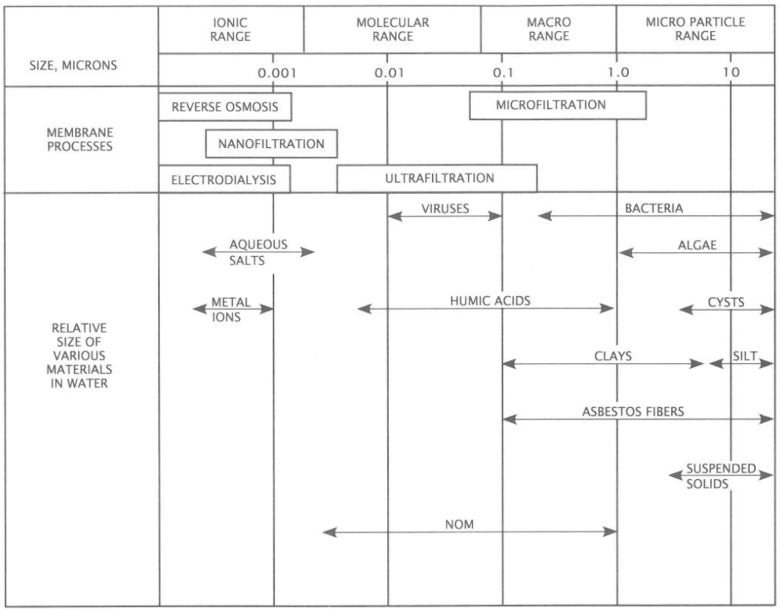


Fig. 16.1 Size ranges of membrane processes and contaminant

(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

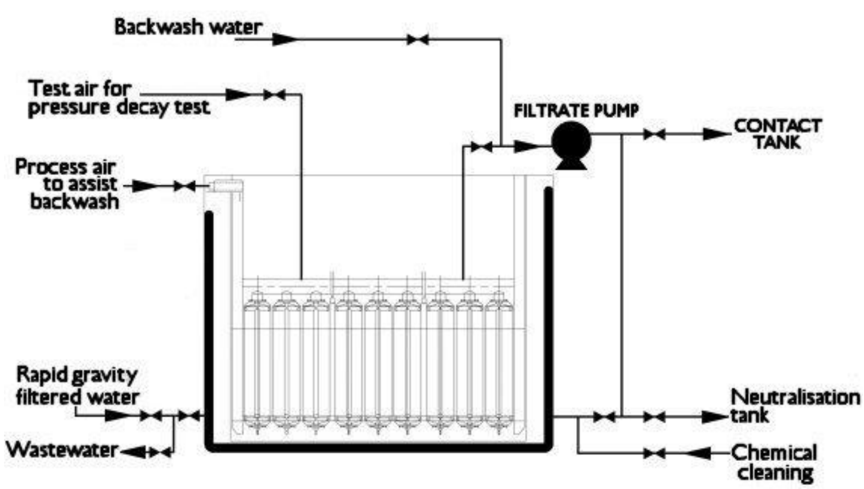


Figure 31 (Courtesy of Portsmouth Water)

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 $^{1}/_{8}$ to $^{3}/_{16}$ 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.

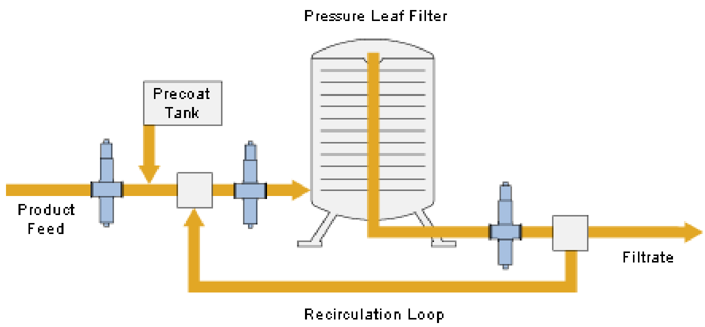


Figure 35 (Courtesy of Optek)

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.

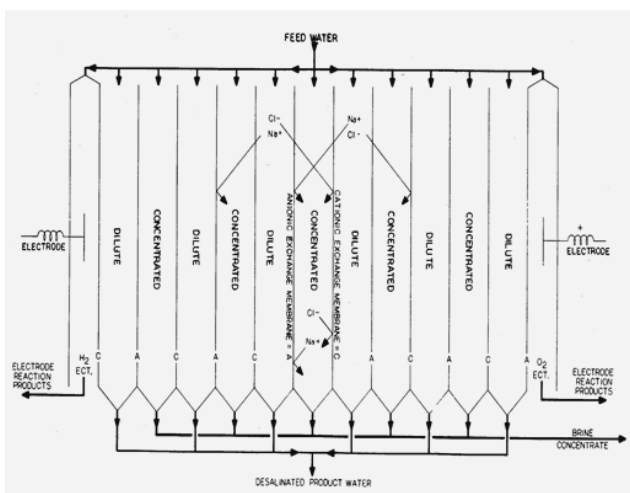


Figure 36 (Courtesy of The Complete Guide of Water Chemistry & Treatment)

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.

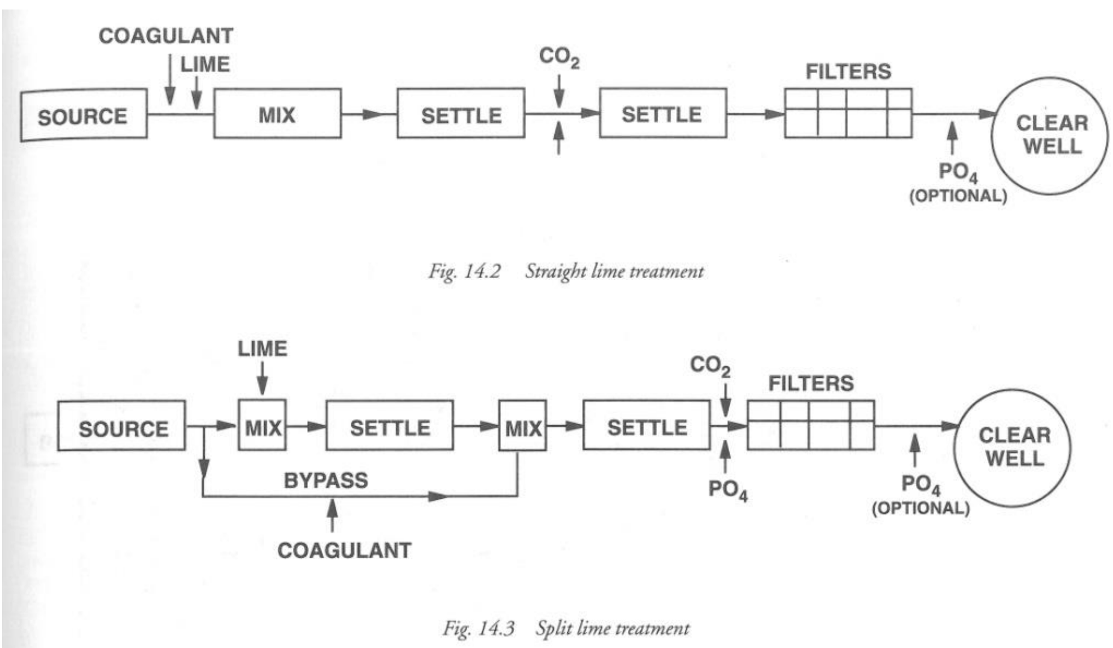


Figure 38 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

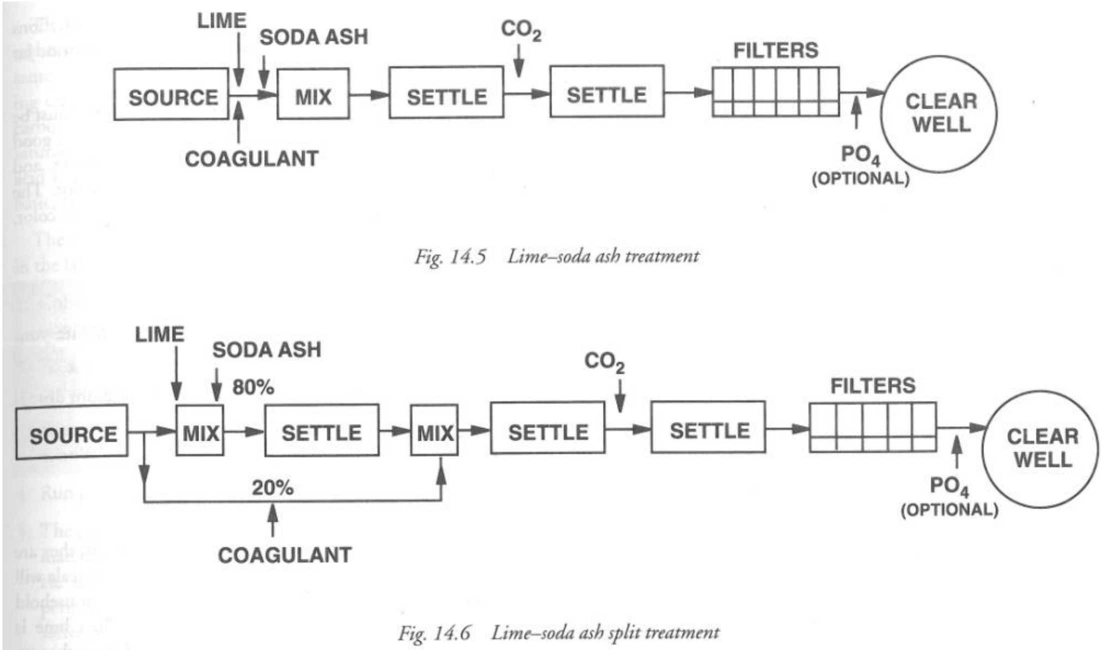
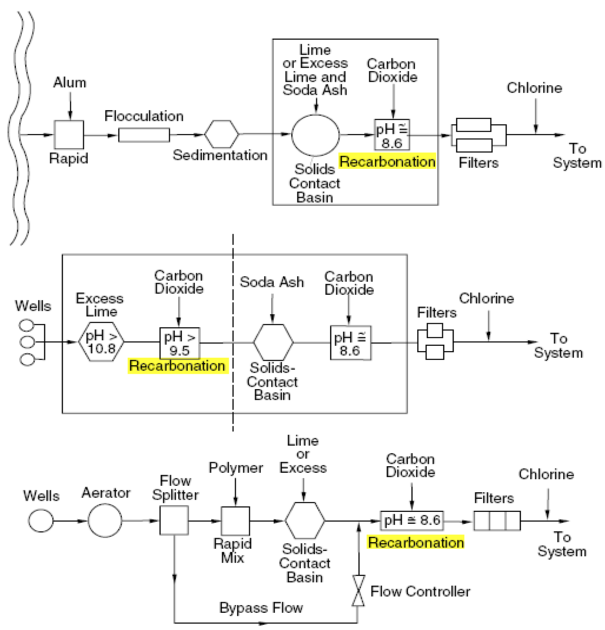


Figure 39 (Courtesy of CSU Water Treatment Plant Operation, Vol. II Fifth Ed.)

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.

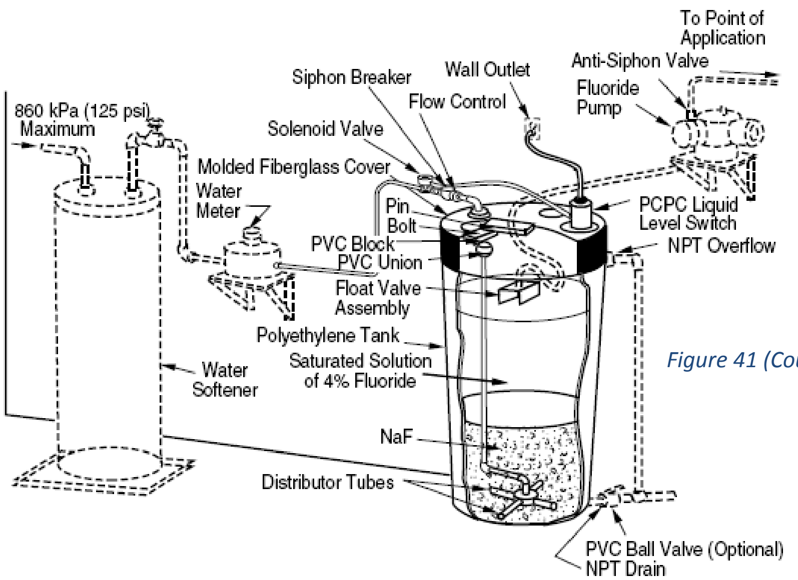


Figure 41 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)

- *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.

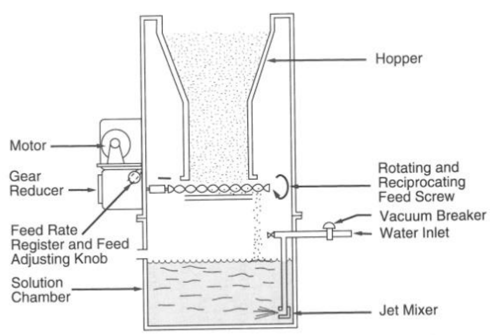


FIGURE 8–1 Screw-type volumetric dry feeder

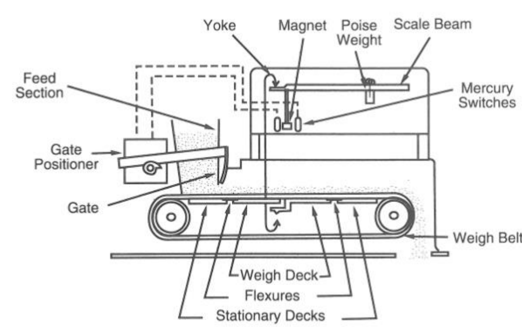


FIGURE 8–3 Belt-type gravimetric dry feeder

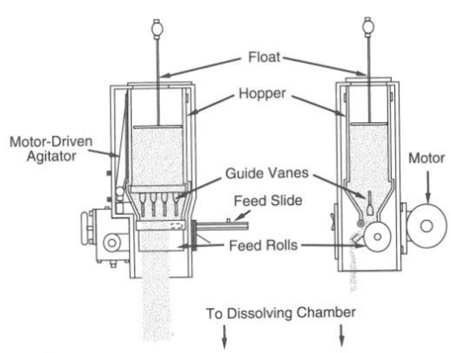


FIGURE 8–2 Roll-type volumetric dry feeder

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.

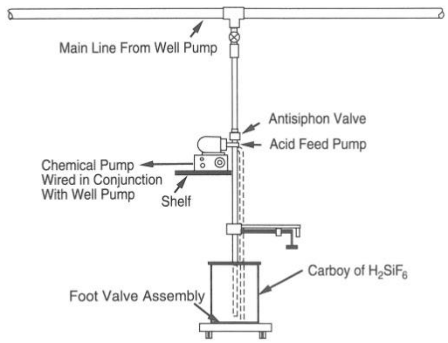


FIGURE 8–7 Acid feed installation

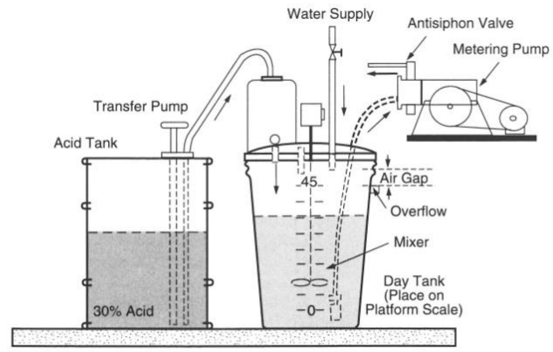


FIGURE 8–8 Diluted-acid feed system

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 ($Ca(OCl)_2$) or sodium hypochlorite ($NaOCl$).

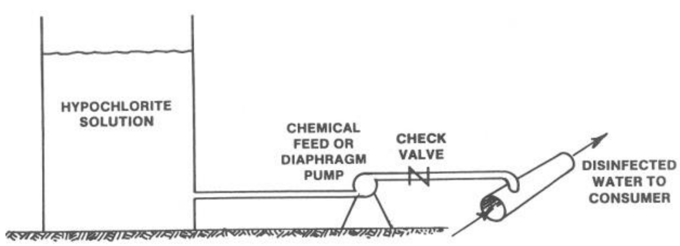


Fig. 7.10 Hypochlorinator direct pumping system

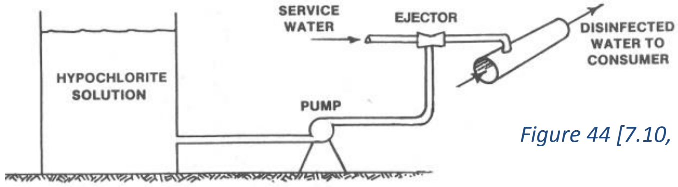


Figure 44 [7.10, 7.11] (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)

NOTE: Pump is chemical feed or diaphragm pump.

Fig. 7.11 Hypochlorinator injector feed system

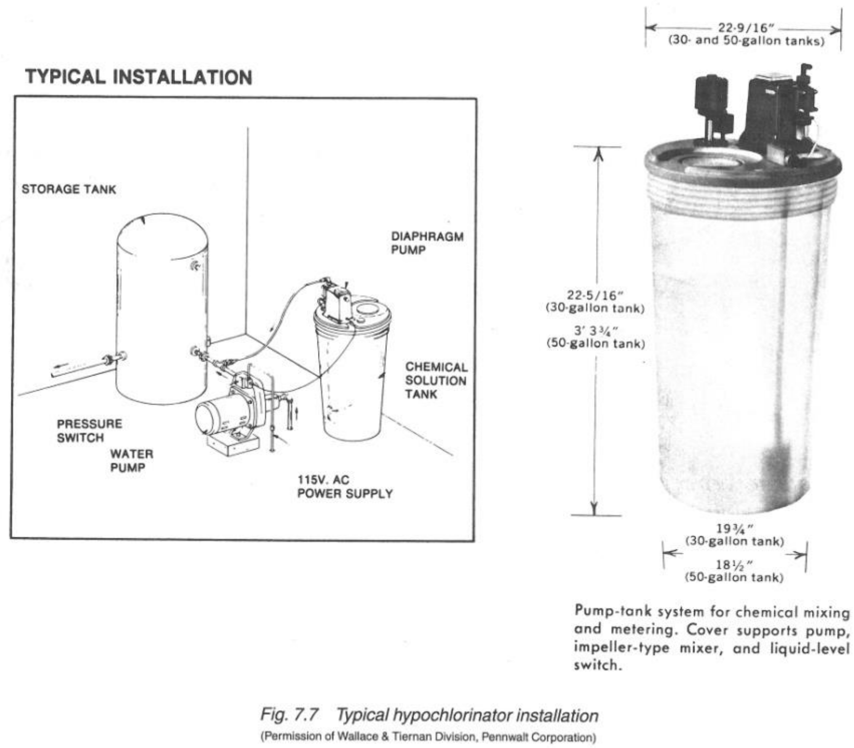


Figure 45 (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)

- *On-site generation of hypochlorites:* Hypochlorites can be generated on-site by combining salt, water, and electricity.
  $NaCl + H_2O \rightarrow NaOCl + H_2$

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

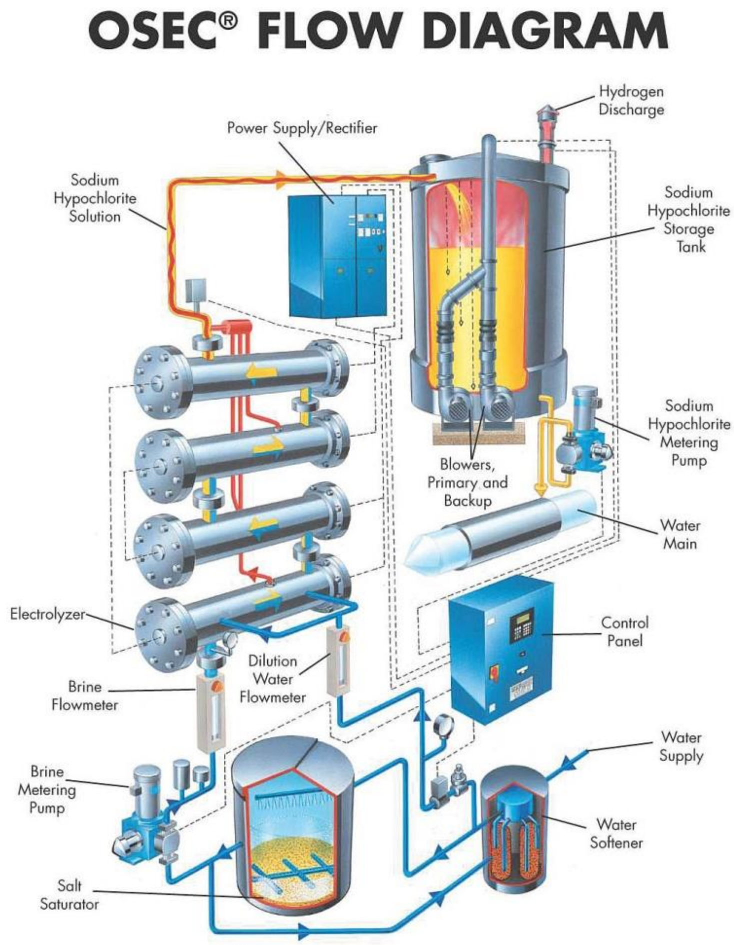
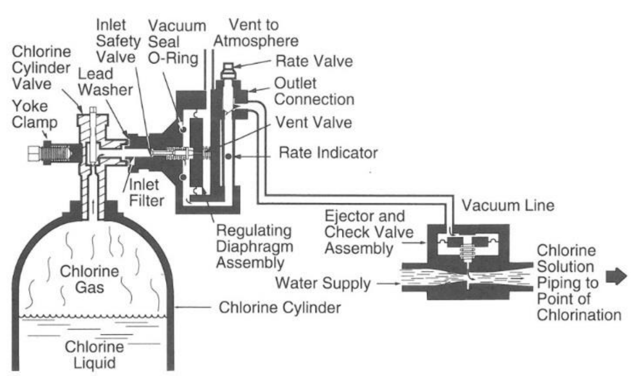


Figure 47 (Courtesy of Wallace & Tiernan OSEC On-Site Hypochlorite Generation Systems)

- *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 ($HOCl \Leftrightarrow OCl^- + H^+$).



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 (Cl_2) and ammonia (NH_3). Ammonia can be added either in liquid or gas form.

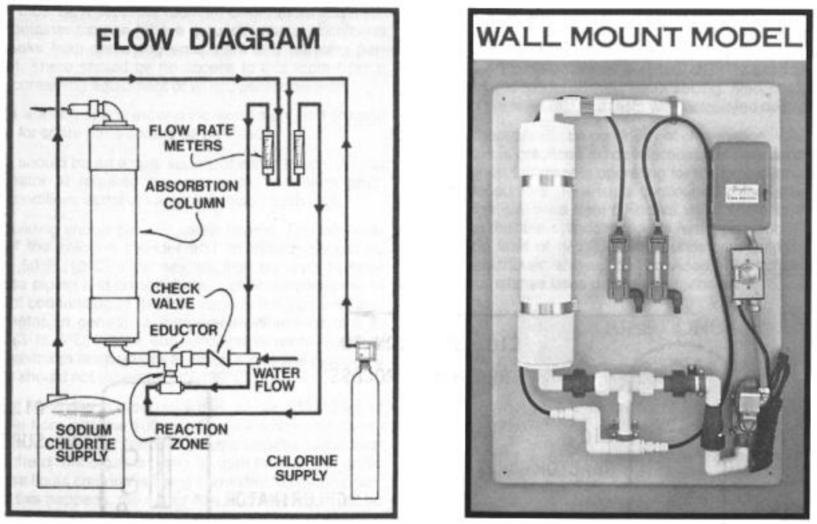
  Ammonia + Hypochlorous Acid → Chloramine + Water

  - *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.

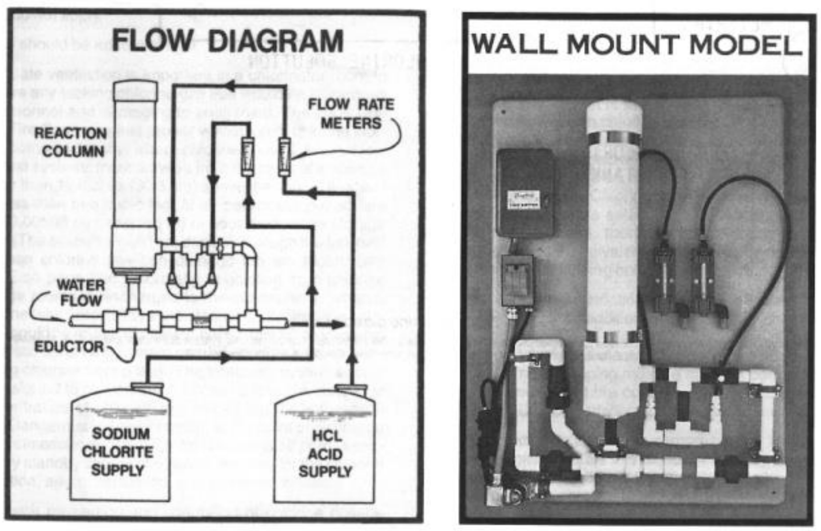
- *Chlorine Dioxide:* A red-yellow gas that is very reactive and unstable. It is a strong oxidizing agent and is also used as a disinfectant. Chlorine dioxide decomposes in water to yield the chlorite ion (ClO_2^-) and, to a lesser extent, the chlorate ion (ClO_3^-).

  Chlorine Dioxide + Water → Chlorate Ion + Chlorite Ion + Hydrogen Ions

  $$2\,ClO_2 + H_2O \rightarrow ClO_3^- + ClO_2^- + 2\,H^+$$



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.

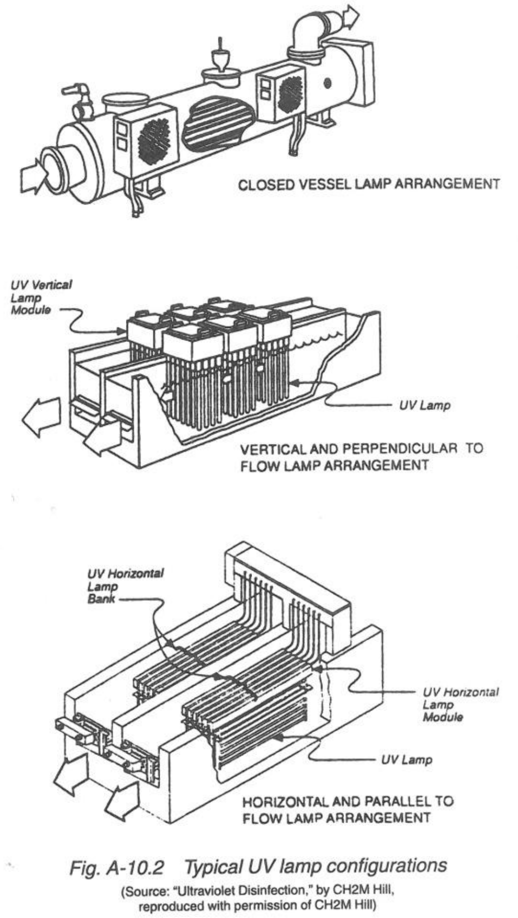
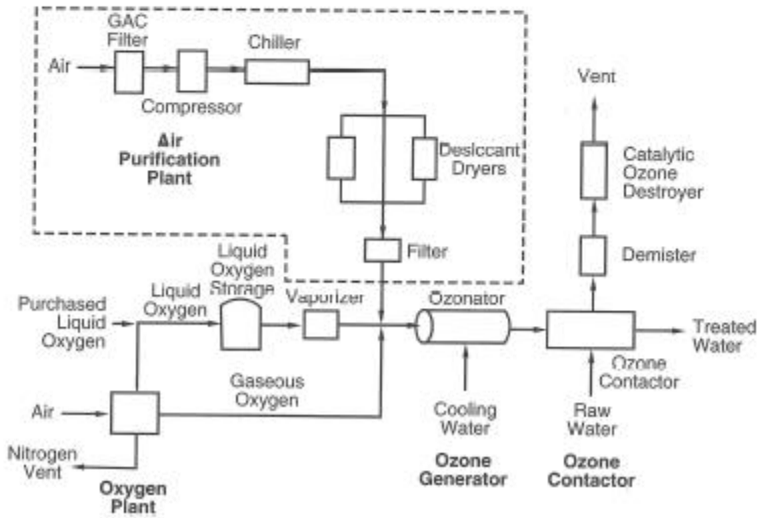


Figure 51 (Courtesy of "Ultraviolet Disinfection")

- *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)

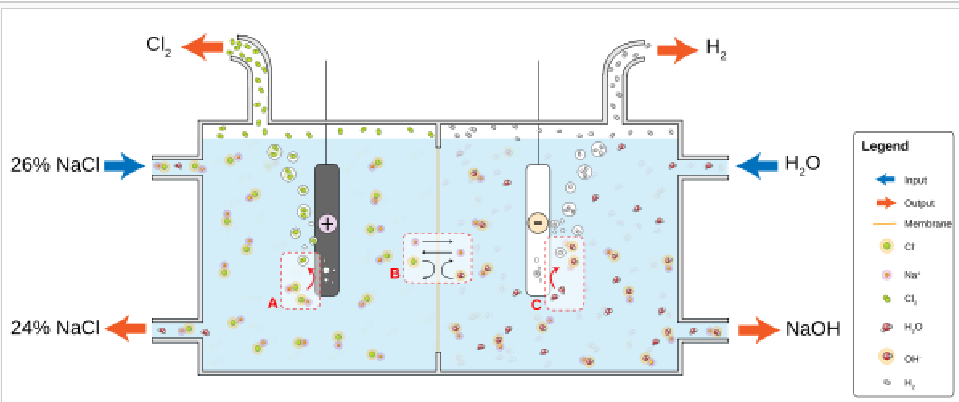


Source: Water Quality and Treatment. *4th ed. (1990).*

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).



Basic membrane cell used in the electrolysis of brine. At the anode (**A**), chloride (Cl^-) is oxidized to chlorine. The ion-selective membrane (**B**) allows the counterion Na+ to freely flow across, but prevents anions such as hydroxide (OH^-) and chloride from diffusing across. At the cathode (**C**), water is reduced to hydroxide and hydrogen gas. The net process is the electrolysis of an aqueous solution of NaCl into industrially useful products sodium hydroxide (NaOH) and chlorine gas.

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

Figure 42 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)
Figure 43 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)
Figure 44 (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)
Figure 45 (Courtesy of CSU Water Treatment Plant Operation, Vol. I, Sixth Ed.)
Figure 46 (Courtesy of Golden Heart Utilities Fairbanks, Alaska)
Figure 47 (Courtesy of Wallace & Tiernan OSEC On-Site Hypochlorite Generation Systems)
Figure 48 (Courtesy of Severn Trent Services)
Figure 49 (Courtesy of Bio-Dynamic)
Figure 50 (Courtesy of Rio Linda Chemical Company)
Figure 51 (Courtesy of "Ultraviolet Disinfection")
Figure 52 (Courtesy of Absolute Ozone - Water Treatment System)
Figure 53 (Courtesy of AWWA WSO: Water Treatment, 3rd Ed.)
Figure 54 (Courtesy of Wikipedia)