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Manual of Naval Preventive Medicine Chapter 7

WASTEWATER TREATMENT AND DISPOSAL, ASHORE AND AFLOAT

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Chapter 7
Manual of Naval Preventive Medicine Wastewater Treatment and Disposal, Ashore and Afloat

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To: Holders of the Manual of Naval Preventive Medicine

1. Purpose. This chapter describes the methods used in wastewater treatment and disposal at naval activities ashore and afloat and prescribes procedures relevant to the prevention of communicable diseases associated with human wastes in the operation and maintenance of these wastewater systems.

2. Background. This revision reflects the latest wastewater system health, sanitation, and preventive medicine requirements, and incorporates recently updated wastewater system information and guidance from the U.S. Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), Naval Sea Systems Command (NAVSEASYSCOM), the Navy Bureau of Medicine and Surgery (BUMED), and applicable government and industry standard organizations.

3. Information Management Control. Reports required in article 7-3, subparagraph 1 of this publication are exempt from reports control per Secretary of the Navy Manual 5214.1 of December 2005, part IV, subparagraph 7k.

4. Action. Replace entire Chapter 7 with this version.

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Acting

Releasability and distribution:
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CHAPTER 7
WASTEWATER TREATMENT AND DISPOSAL ASHORE AND AFLOAT

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SECTION I. GENERAL INFORMATION

7-1. Scope. This chapter describes the methods used in wastewater treatment and disposal at naval activities ashore and afloat and prescribes procedures relevant to the prevention of communicable diseases associated with human wastes in the operation and maintenance of these wastewater systems. This chapter is not intended as a technical guide for treatment plant operation.

7-2. Definitions

1. Aerobic Waste Treatment. The stabilization of wastes through the action of microorganisms in the presence of oxygen.

2. Anaerobic Waste Treatment. Waste stabilization brought about through the action of microorganisms in the absence of air or elemental oxygen.

3. Comminutor. A comminutor is a motor driven grinder used to pulp or liquefy sewage solids before they enter wastewater treatment system.

4. Contiguous Zone. A zone of the high seas, established by the United States under the Convention of the Territorial Sea and the Contiguous Zone, which is contiguous to the territorial sea which extends nine nautical miles (nm) seaward from the outer limit of the territorial sea.

5. Cross Connection. Any actual or potential connection between the potable water supply and a source of contamination or pollution.

6. Effluent. Wastewater or other liquid partially or completely treated or in its natural state flowing out of a reservoir, basin, sewage treatment plant, industrial plant, or marine sanitation device.

7. EPA. The abbreviation for the Environmental Protection Agency.

8. Facultative Anaerobic Bacteria. Bacteria which can adapt to grow in the presence of, as well as the absence of, oxygen.

9. Graywater. Refers to ship generated wastewater from deck drains, lavatories, showers, dishwashers, water fountains, and laundries, as well as discarded water from shipboard medical facilities. It does not include industrial wastes, infectious wastes, and human body wastes.

10. Inland Waters. Inland waters are generally navigable fresh or brackish waters upstream from coastal territorial waters.

11. Marine Sanitation Device (MSD). Any equipment on board a ship or craft which is designed to receive and treat sewage to a level acceptable for overboard discharge; or which receives and retains sewage on board for later discharge ashore; or in waters where discharge is permissible. Within the generic term "MSD," the Navy uses these terms to identify the general types:

a. Type I. "Flow-through" and "discharge" device designed to receive and treat sewage aboard ship and produce an overboard effluent with a fecal coliform count of not more than 1,000 per 100 milliliters and no visible solids. These systems are no longer authorized or used onboard U.S. naval vessels.

b. Type II. "Flow-through" and "discharge" device that produces an overboard effluent with a fecal coliform count of not more than 200 per 100 milliliters and total suspended solids of not more than 150 milligrams per liter.

c. Type III-A. "Nonflow-through" device designed to collect shipboard sewage by means of vacuum or other reduced-flush systems and treat and hold the sewage while transiting navigable waters.

d. Type III-B. Collection, holding, and transfer (CHT) system designed to collect both sewage and graywater while in port; to offload sewage and graywater to suitable shore receiving facilities; to hold sewage while transiting navigable waters; and to discharge overboard both sewage and graywater while operating beyond navigable waters. Most CHT systems consists of collection and discharge piping, pumps, strainers (removed from most ships), an aeration system (only on ships with sewage tanks of 2,000-gallon capacity), and collection and holding tanks.

12. Navigable Waters of the United States. The coastal territorial waters (sea) of the United States, the inland waters of the States, including the United States portion of the Great Lakes, the St. Lawrence Seaway, and the Panama Canal.

13. Restricted Zone. The navigable waters of the United States, 0 to 3 nm from shore.

14. Sewage. Sewage when referred to in shipboard application, is defined as wastes of human origin from water closets and urinals and transported by the ship's soil drain system. Sewage is also referred to as black water. When referred to in shore-based treatment applications, the term "sewage" may include a combination of black water and other wastewater.

15. Soil Drains. Drains which collect sewage from toilets and urinals.

16. Territorial Sea. The belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea, and the line marking the seaward limit of inland waters and extending seaward a distance of 3 nm.

17. Wastewater. The spent water of a ship, base, industrial plant, or other activity. From the standpoint of source, it may be a combination of the liquid and water carried wastes from soil and waste drains of ships, industrial plants, housing areas, and institutions, together with any groundwater, surface water, or storm water that may be present.

18. Waste Drains. Drains which collect wastewater (graywater) from showers, laundries, and galleys, etc.

7-3. National Effluent Guidelines

1. The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) established the National Pollutant Discharge Elimination System (NPDES) which is a program to control water pollution in the nation's waterways by limiting the discharge of polluted effluents into the navigable waters from point sources. Each industrial, agricultural, and municipal wastewater discharger is required to obtain a discharge permit from the Environmental Protection Agency (EPA) or State regulatory agency, which sets an effluent limitation for that activity based on the national effluent limitation guidelines published by the EPA. Under this system, the discharger is required to monitor its own discharges of pollutants and submit periodic reports to the control agency. If the discharger cannot comply immediately with established limitations, the permit includes a schedule which sets forth specific dates when the required reduction of pollutants must be achieved. Non-compliance with NPDES permits carries a maximum penalty of $50,000 per day and 2 years in prison.

2. Information regarding the effluent guidelines is published in 40 CFR 100-149. This document is available through the Government Printing Office, Washington, DC 20402.

3. In addition, the EPA published 40 CFR 1700 on the Uniform National Discharge Standards for Vessels of the Armed Forces (UNDS). UNDS provides standards for discharges incidental to the normal operation of a vessel, including graywater, but does not revise or impact the existing discharge requirements for sewage.

7-4. Policy

1. The above legislation and Executive Order 12088 require Federal agencies to conform to Federal, State, and local pollution control regulations and provide leadership in the protection and enhancement of the quality of air, water, and land resources. Installation, operation, and maintenance of shipboard pollution control equipment and systems is mandatory. Shipboard personnel must use existing pollution control equipment and procedures to prevent pollution of the seas and coastal areas. This will effectively protect and enhance the water quality of these areas and prevent possible litigation against the Navy.

2. OPNAVINST 5090.1E, Environmental Readiness Program, is the published Navy policy and assigned responsibilities for Navy-wide actions for prevention, control, and abatement of environmental pollution caused by naval ships and facilities. The policy listed in the OPNAVINST 5090.1E:

a. The Navy will actively participate in a program to protect and enhance the quality of the environment through strict adherence to all applicable regulatory standards, positive planning, and programming actions to control pollution caused by Navy facilities, and establishment of methods to monitor the effectiveness and compliance of such actions.

b. Executive Order 12088, requires Navy shore facilities and forces afloat, as appropriate, to cooperate with Federal, State, and local environmental protection organizations and comply with the official substantive standards and criteria promulgated by such agencies. The Clean Water Act of 1977, PL 95-217, requires naval facilities to comply with State or local administrative procedures for pollution abatement and control. Where, in the interest of national defense or other relevant reasons, it is considered impractical to comply with standards and criteria, the matter must be referred to the Chief of Naval Operations, via the chain of command, for resolution.

c. Naval installations overseas must cooperate with foreign host nations and communities and, to the extent practicable, provide pollution abatement measures equal in degree and timing to those of host nations. Navy ships in foreign harbors and units overseas must conform to environmental quality standards set forth in applicable international, bilateral, and Status of Forces Agreements to which the U.S. Government is a party.

d. DoD Manual 4715.06 Volumes 1 and 4 governs the design, construction, installation, and operation of MSDs and marine pollution control devices, respectively, aboard vessels owned and operated by Department of Defense. Navy vessels with installed toilets must be equipped with MSDs designed to prevent the discharge of untreated or inadequately treated sewage, or of any waste derived from sewage (e.g., sludge), within 0-3 nm of the United States. Ships will have the capability to collect and transfer graywater to shore while pierside and minimize discharge within 1 nm. Graywater combined with sewage on a vessel will be considered sewage.

7-5. Responsibilities

1. The Chief of Naval Operations promulgates Navy policy and assigns responsibilities concerning prevention, control, and abatement of environmental pollution caused by naval ships and shore stations. See OPNAVINST 5090.1E and Naval Ship’s Technical Manual (NSTM), Chapter 593, Pollution Control.

2. The Commander, Naval Facilities Engineering Command (NAVFACENGCOM) through the Naval Facilities Engineering Commands (FEC) provides technical assistance on compliance with the permit system to area coordinators and naval activities. FECs also serve as the principal contact point between naval commands and EPA regional offices, in obtaining permit application formats and forwarding completed applications.

3. The Chief, Bureau of Medicine and Surgery (BUMED), through the preventive medicine services at Navy medicine readiness and training commands, Navy and Marine Corps Force Health Protection Command (NMCFHPC), and Navy environmental and preventive medicine

units, is responsible for evaluation of wastewater disposal systems ashore and afloat as they relate to potentially hazardous conditions which could adversely affect the health of Navy military and civilian personnel.

4. NAVSEASYSCOM is the technical authority responsible for design, certification, and approval of MSDs and shipboard wastewater systems. Commander, Military Sealift Command is the authority responsible for in-service USNS vessels' MSDs.

5. Local commanders are responsible for obtaining a discharge permit and ensuring the operation of wastewater treatment facilities and quality of all applicable effluents discharged into navigable waters are in compliance with the permit.

7-6. Navy Discharge Permit Requirements. Discharge permits are required for all naval activities that discharge domestic or industrial wastes into navigable waters or the waters of the contiguous zone or the oceans. Navy shore facilities which discharge into publicly owned treatment works or non-Navy-owned sewage systems require permits to provide pretreatment of industrial wastes. Ships, boats, and yard craft, storm sewer outlets which do not receive polluted effluents; and injection wells or agriculture projects are exempt from discharge permit requirements. Permit applications are completed by FECs for submittal to EPA or the State as appropriate. Applications must be filed 180 days prior to the date the discharge is to begin. Most permits are valid for 5 years and reapplication is required 180 days in advance of the expiration date.

SECTION II. WASTEWATER TREATMENT AND DISPOSAL SYSTEMS ASHORE

7-7. Introduction

1. Sewage may be treated by a wide variety of methods using simple settling techniques or sophisticated engineering systems. Cesspools, septic tanks, and Imhoff tanks are all examples of simple self-contained systems used for wastewater treatment. More advanced systems are defined by the level of sewage treatment they provide. These methods are referred to as:

a. Primary treatment (with or without chemicals)

b. Secondary treatment (biological treatment)

c. Tertiary treatment (advanced wastewater treatment)

2. Primary treatment consists of methods designed to remove a considerable portion of the suspended solids and colloidal substances. Primary treatment is used for the removal of floating and suspended solids, neutralization, and equalization, and to prepare the wastewater for subsequent treatment or discharge.

3. Secondary treatment oxidizes the suspended solids and the organic solids in solution that remain after primary treatment. The principal methods of secondary treatment are activated sludge and trickling filters. Stabilization ponds are another method of secondary treatment, often used where large land areas are available and a high-quality effluent is not always required.

4. Tertiary treatment or advanced wastewater treatment is defined as treatment of wastewater for the removal of pollutants not removed by conventional biological treatment processes (activated sludge, trickling filters, oxidation ponds, etc.). These pollutants include suspended solids, biological oxygen demand (BOD), refractory organics (reported as total organic carbon or chemical oxygen demand (COD)), nutrients (nitrogen and phosphorus), and inorganic salts. Advanced wastewater treatment is also associated with the term “water reclamation,” which is a system that employs a combination of conventional and tertiary treatment processes that returns the wastewater to its original quality.

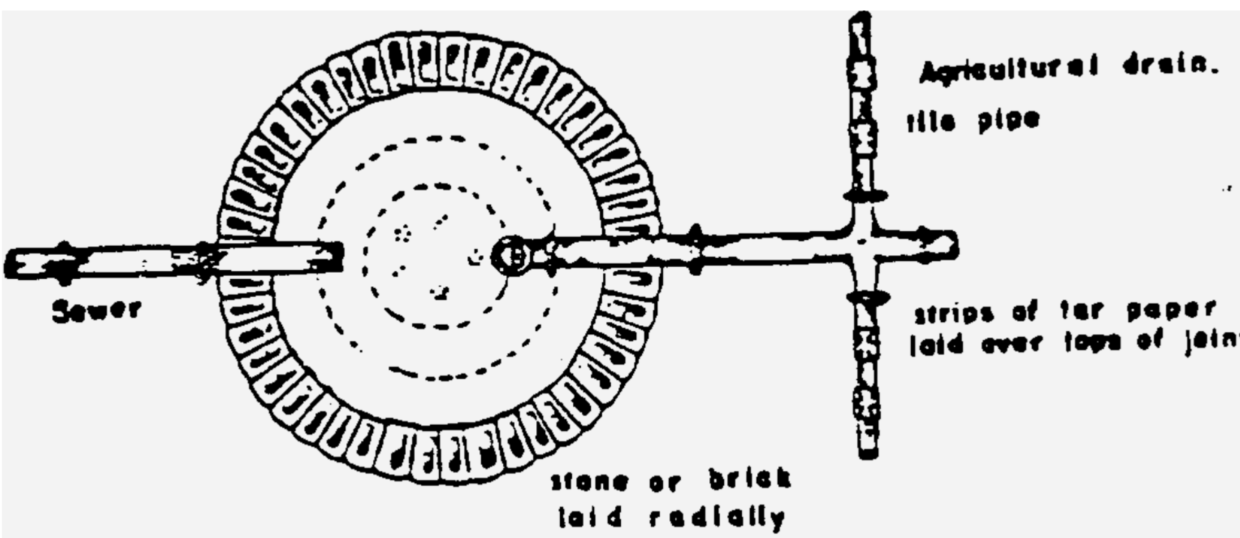
7-8. Individual Sewage Disposal Systems

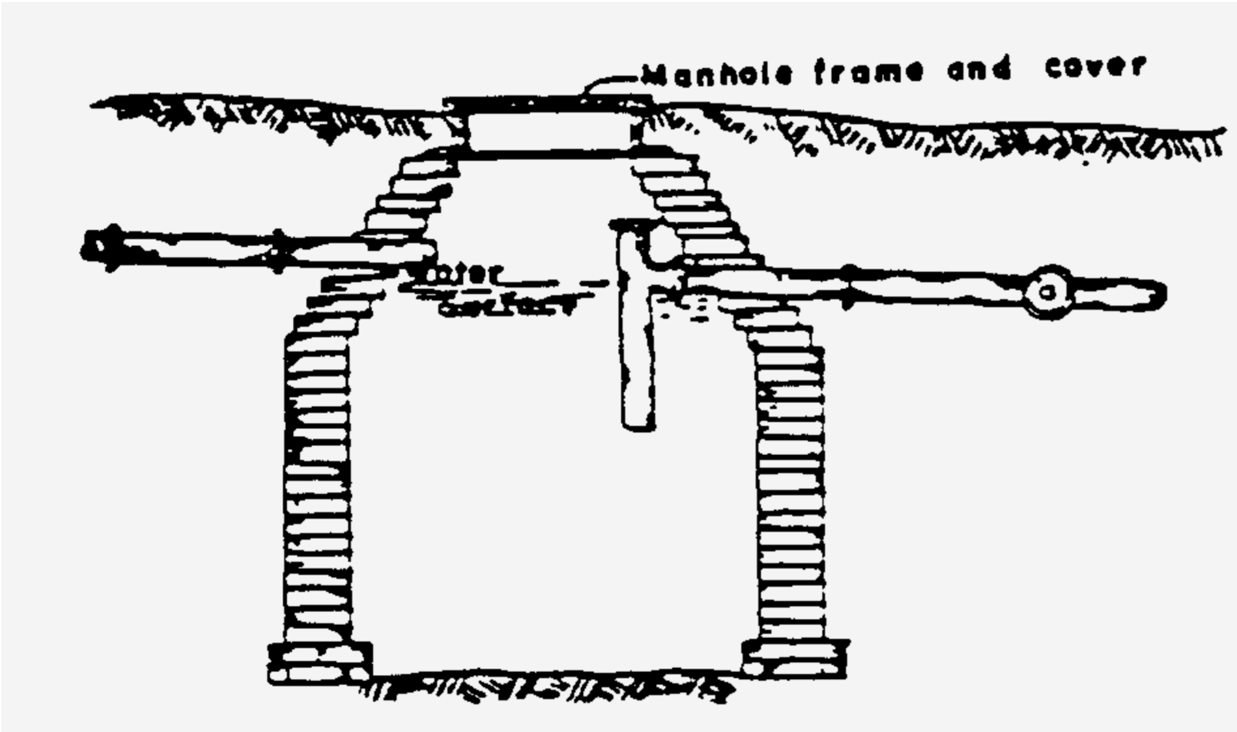
1. Pit Privy. The pit privy is the most primitive of all the individual sewage disposal systems. This type of system is no longer authorized at naval activities (except in field conditions such as bivouacs). It consists of a hole in the ground with the toilet seat located directly over it. A variation of the pit privy is the bored-hole latrine which is a hole 10-25 inches in diameter and 15-25 feet deep. A concrete slab is usually placed over the hole. The location of a privy is critical. Whenever possible, it should be located down-slope from a well. In some special cases, however, where the soil is uniformly compact and the ground water does not enter the pit, or the pit itself does not penetrate the water table, a privy may be constructed up-slope from a well.

When this is done, the privy must be at least 100 feet from the well, particularly if there is the possibility that the water table may rise into the privy during a period of heavy rain. If the water table is permanently within a few feet of the ground surface, conditions are not favorable for a pit privy. Other variations on the pit privy include the vault toilet and chemical toilet. A vault toilet consists of a water-tight concrete vault over which a toilet seat is placed. It is used where soil conditions do not favor a pit privy. Vault toilets must be periodically emptied and are not an efficient waste disposal method. A chemical toilet consists of a tank with a capacity of about 45 gallons per seat. The operation of this system depends on the action of a caustic disinfectant and water. The solution is used to kill the bacteria and liquify the solids. As with the vault toilet, this system must be periodically emptied. In addition, the system must be recharged with the full amount of chemical. All these systems are subject to the problems of odor production and insect breeding when not properly maintained.

2. Cesspools. A cesspool (Figure 7-1) is simply a covered pit into which raw sewage is emptied. Unlike the pit privy, it is designed to function with a water carriage system. The cesspool is the reverse of a well. The sides are usually lined with brick or stone masonry, and the joints laid without mortar so that the sewage can leach out. Liquids leach into the soil and solids remain in the pit where they decompose. Household wastes containing grease, oil, soaps, and other insoluble substances are deposited on the walls and bottom of the cesspool impeding the leaching process. Soon the system becomes a septic tank. Because there are no provisions for the subsurface distribution of the liquid effluent, cesspools often overflow, discharging onto the ground surface. To prevent this, cesspools must be cleaned frequently.

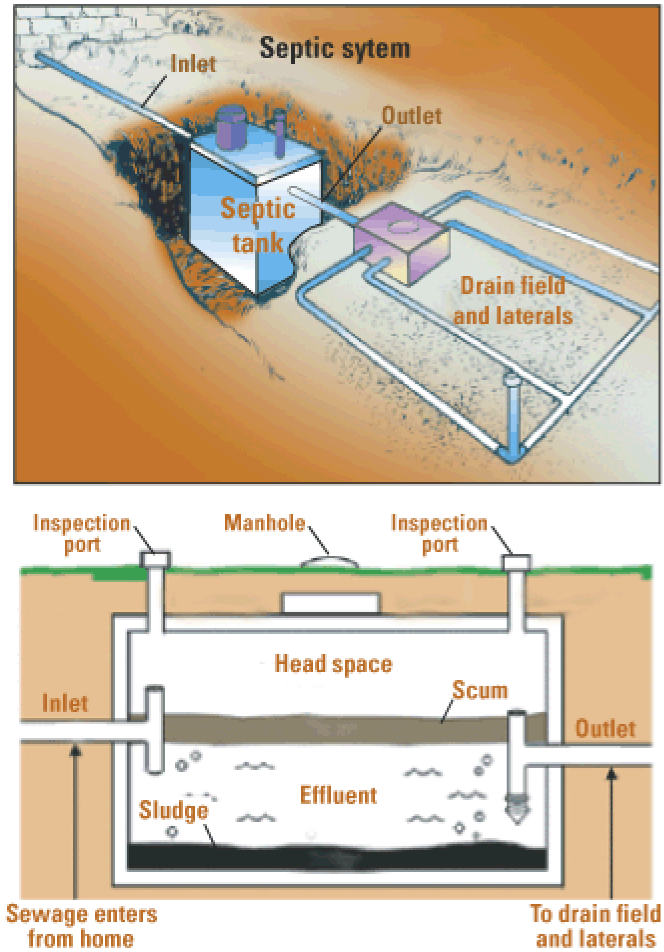
Figure 7-1. Leaching Cesspool (Rarely Used)





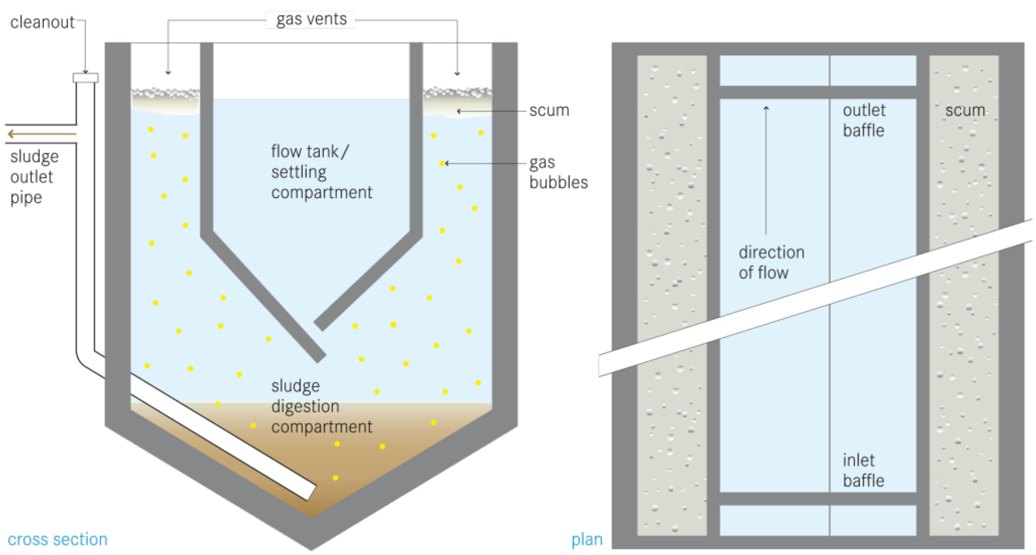
3. Septic tanks. A septic tank (Figure 7-2) is a watertight tank placed underground into which raw sewage flows by gravity. Sewage is discharged into the tank where a series of baffles are placed to slow the flow, allowing the solids to settle and be retained. During this retention period, 50 to 70 percent of the suspended solids are removed. The solids are then reduced in volume by the biological action of anaerobic and facultative bacteria. This process is known as digestion and during the process most pathogenic organisms are destroyed; however, the liquid effluent may still contain some pathogenic organisms and is still putrescible. The septic tank discharges through an opening near the top placed at the end opposite the influent. The effluent is disposed of using a network of concrete or clay pipe laid with open joints, or perforated polyvinyl chloride (PVC) pipe which permits wastewater to percolate into and through the soil. Filtration by the soil removes more of the suspended matter and aerobic bacteria stabilize the organic matter remaining in the effluent. It is important that leach fields be naturally drained, permeable, and of sufficient area. Areas with heavy clay soils and limestone formations are not acceptable for leach fields.

Figure 7-2. Typical Septic Tank



4. Imhoff tanks. The Imhoff tank (Figure 7-3) obtained its name from its inventor, Dr. Karl Imhoff of Germany. It is a variation of the septic tank in which two chambers are provided, one above the other. The upper sedimentation or flow chamber is for settling solids and the lower chamber is for anaerobic digestion of sludge. Solids settle to the bottom of the flow chamber passing through as clot at the bottom into the lower chamber. The slot is baffled in such a manner that gas rising from the lower chamber does not interfere with the sedimentation process in the upper chamber. A gas vent, known as the scum chamber, extends from the lower compartment up to the tank surface between the outside wall of the sedimentation chamber and the Imhoff tank enclosing wall. The main advantage of this type of tank over the septic tank is that sludge is separated from the effluent, which allows for more complete settling and digestion. Operated properly, these systems can remove 30 to 60 percent of the suspended matter, and from 25 to 40 percent of the BOD 5. *Other Non-Sewered Waste Disposal Systems.* This category of waste disposal systems includes various portable or temporary toilets such as chemical toilets, combustion toilets, vaulted toilets, and recirculating toilets. The standards for these devices must not be less than those established by the American National Standards Institute, Inc. (ANSI) Z4.3-1979 "Minimum Requirements for Non-Water Carriage Disposal Systems" or its subsequent revisions.

Figure 7-3. Typical Imhoff Tank

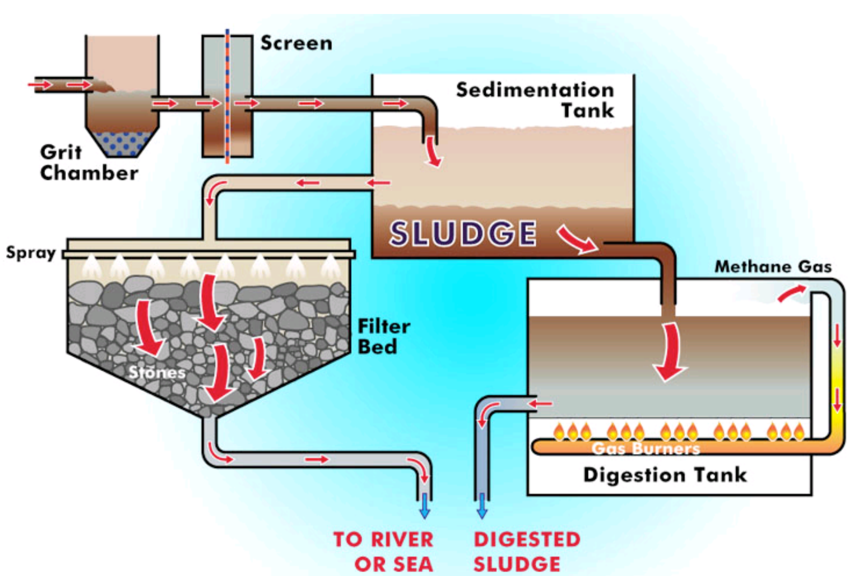


7-9. <u>Community Wastewater Treatment Systems</u>

1. Primary treatment

a. General. Primary treatment is designed to remove the suspended solids from raw wastewater (Figure 7-4). This is accomplished by mechanical means such as screening and sedimentation; however, additional treatment is required before the wastewater will meet EPA and State effluent standards.

Figure 7-4. Schematic diagram of primary sewage treatment



b. Screening. Various forms of screens are used to remove large solid materials from influent wastewaters that could clog or damage pumps or otherwise hinder the flow of sewage through the plant. The screening devices take various forms depending on the existing conditions at each locality and the plant design. They include racks and bar screens which intercept large debris; perforated plates and fine screens to remove smaller objects; and comminutors and cutting screens which reduce the size of the solids.

c. Wet Wells. Flow through the treatment system is often regulated by a wet well which collects the fluctuating flow of influent wastewater and feeds it through the system at a relatively even rate.

d. Grit Chambers

(1) Grit chambers are designed to remove sand and other gritty material that may damage pumps and valves, accumulate in sedimentation tanks or clog sludge drains. They are particularly important in plants that receive wastewater from combined storm and sanitary sewers since the influent from the sewers is high in gritty material.

(2) The grit is removed when the velocity of the wastewater is decreased sufficiently to cause the heavy inorganic materials to settle while the organic solids remain suspended. There are usually two grit chambers arranged in parallel so that one remains in operation while the other is cleaned.

(3) The accumulated grit is removed from the chamber either manually or mechanically. The washed grit is relatively inoffensive and can be used in landfills.

e. Sedimentation Tanks

(1) Sedimentation involves removal of a large part of the suspended solids from raw wastewater. Sedimentation is used in both primary and secondary treatment processes and, when employed in a primary treatment process, is designated as “primary sedimentation.”

(2) Plain sedimentation and chemical precipitation are two types of sedimentation used in wastewater treatment operations.

(a) Plain sedimentation with separate sludge removal is a common practice. The influent enters either a circular or rectangular sedimentation tank (Figures 7-5 and 7-6) where the flow rate is slowed and distributed evenly across the tank by a system of baffles, weirs, and multiple inlets. The slow even flow allows solids to settle to the bottom of the tank as sludge. The sludge is removed from the bottom of the sedimentation tank to a digester through pipes under hydrostatic pressure or suction. The sludge must be routinely removed to prevent its decomposition in the sedimentation tank resulting in the release of gases to the surface which would hinder effective settling and produce malodors.

(b) Chemical precipitation of wastewater is sometimes used to enhance the settling process. In this method chemicals such as lime, alum, ferrous sulfate, and ferric chloride are added to the wastewater before it enters the sedimentation tank. As the chemicals mix with the wastewater, they form an insoluble gelatinous floe which settles rapidly, carrying with it most of the suspended solids in the wastewater. This method is most often used when industrial wastewaters are being treated.

Figure 7-5. Rectangular sedimentation tank, chain sludge collector

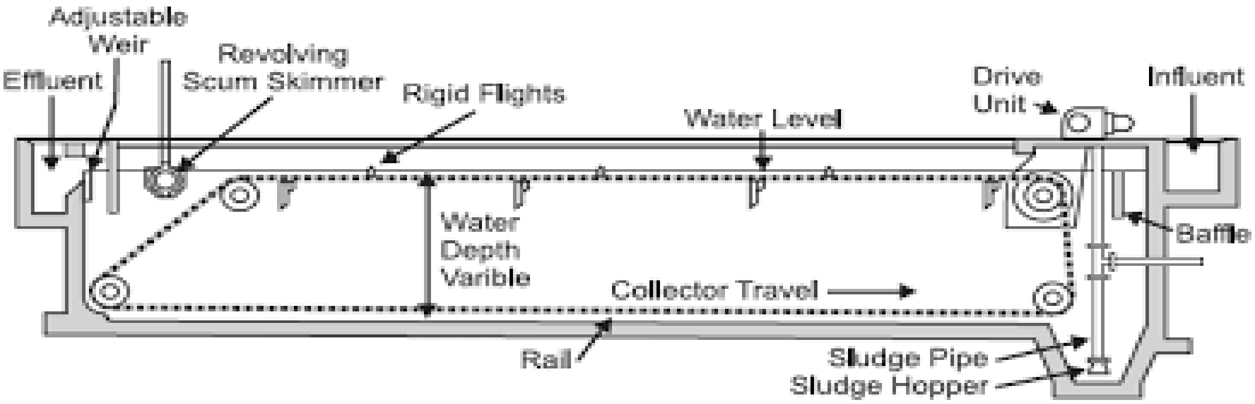
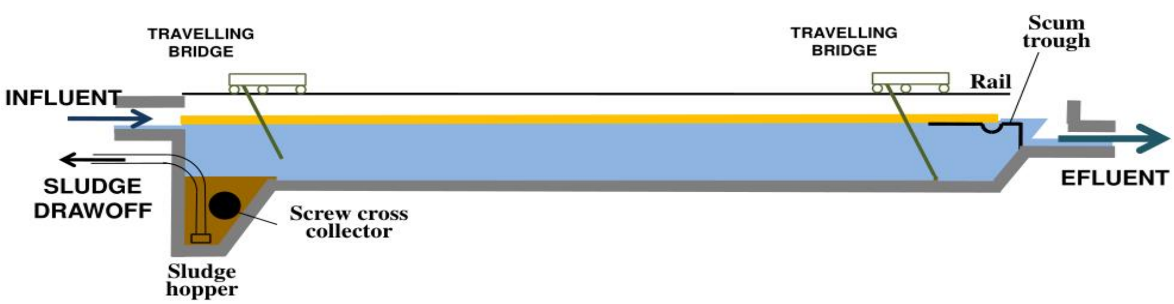


Figure 7-6. Rectangular Sedimentation tank, traveling bridge collector



(3) Mechanical skimming devices are installed on most sedimentation tanks to remove scum and oil products which float on the surface of the wastewater.

(4) The outlet weir of the sedimentation tank extends across the full width of rectangular sedimentation tanks and around the periphery of circular ones to ensure a smooth even flow. The effluent continues to secondary treatment or to final disposition.

f. Efficiency. Primary treatment removes only a portion of those substances which are in the suspended state, leaving the colloidal and dissolved substances in the liquid effluent. Between 40 to 75 percent of the suspended matter is removed depending on the concentration, the retention time in the sedimentation tank, and the evenness of distribution and flow in the tank. The BOD is reduced 30-40 percent.

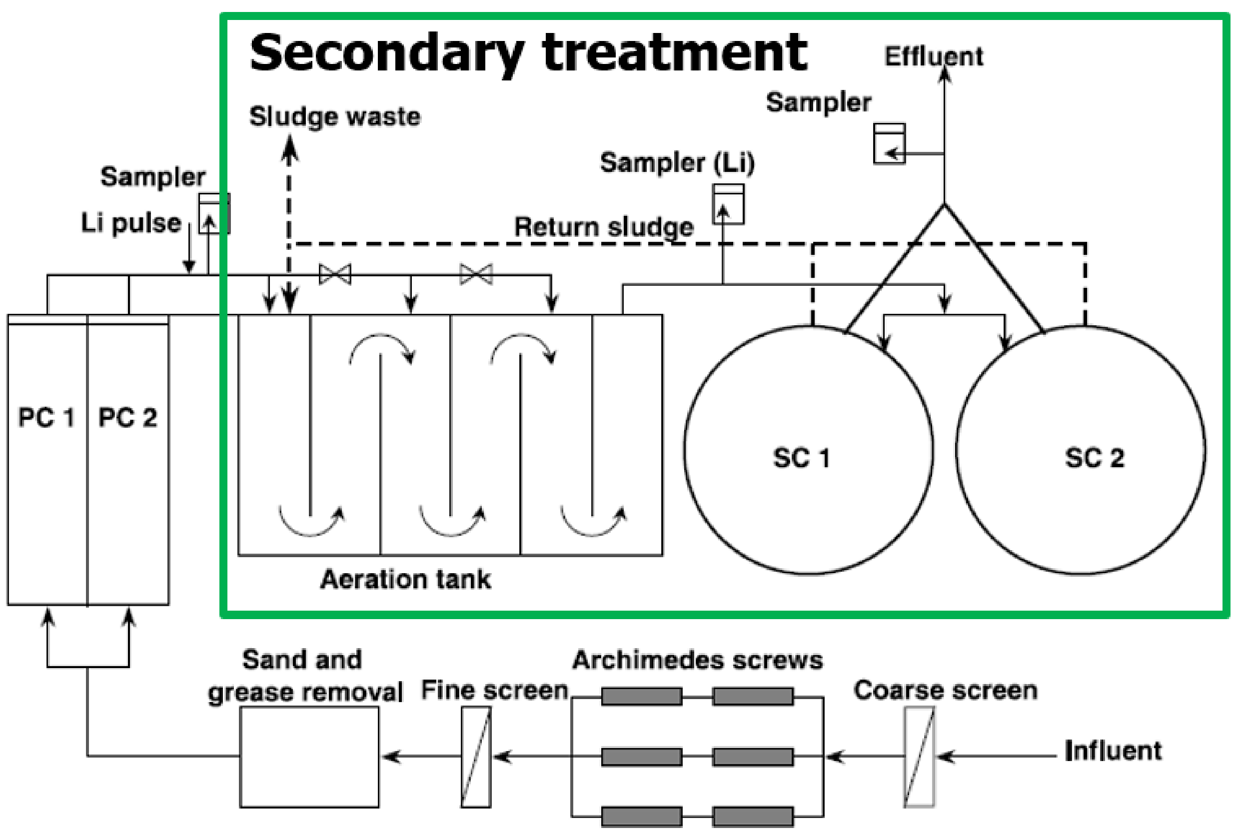
2. Secondary Treatment

a. General. Secondary treatment involves removal of most of the colloidal and dissolved organic materials in the wastewater. This is usually accomplished under aerobic conditions by biological oxidative decomposition and production of biological growths that are removed in secondary sludge. Activated sludge, trickling filters, and stabilization ponds are most often used to maintain aerobic conditions and the intimate contact between the wastewaters and organisms necessary for the removal of the pollutants.

b. Activated sludge

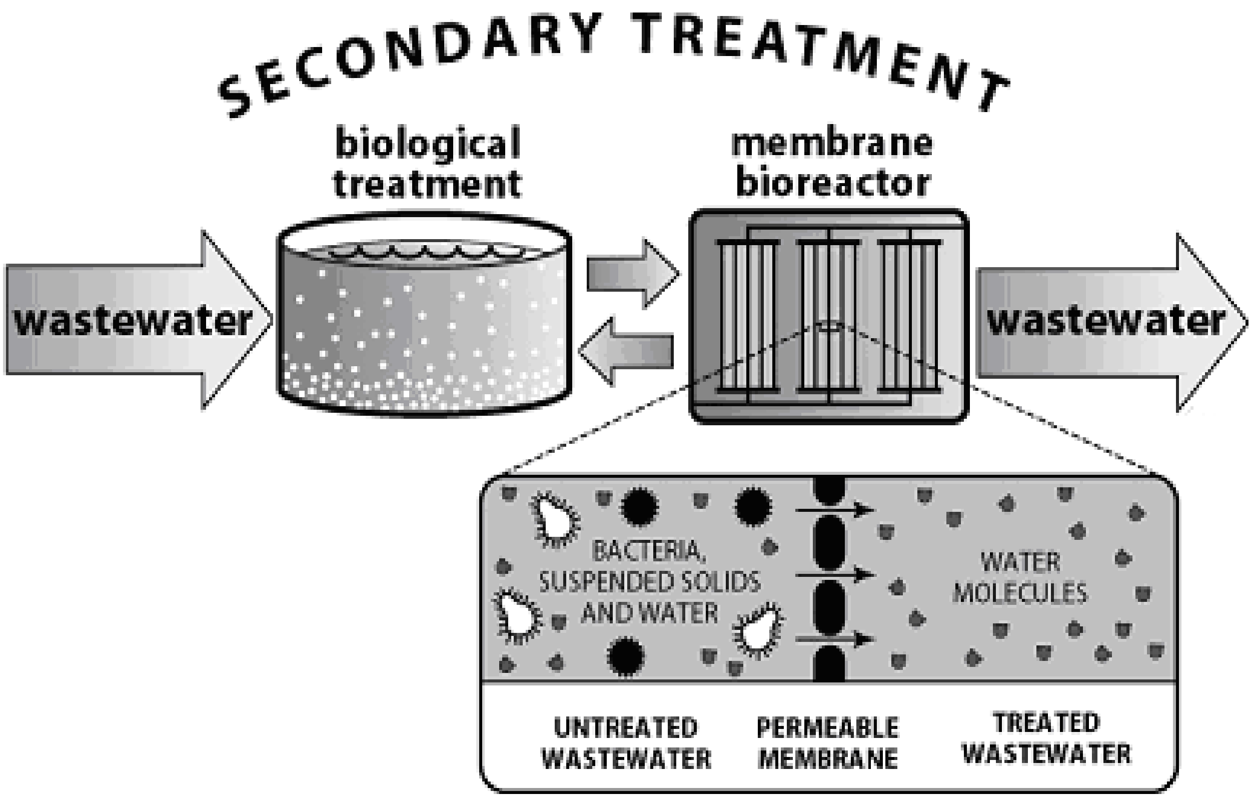
(1) In the activated sludge process of wastewater treatment (Figures 7-7 and 7-8), effluent from the primary sedimentation tank flows into an aeration chamber where it is mixed with sludge that has been aerated and thereby "activated" with aerobic bacteria to form a mixed liquor. The mixed liquor is thoroughly agitated by compressed air which is applied through diffusers or jets at the bottom of the aeration tank or by a stirring device which agitates the mixed liquor so air can be absorbed from the atmosphere. Wastewater is continually fed into the aeration chamber where microorganisms within the activated sludge act upon the organic wastes.

Figure 7-7. Schematic flow diagram of secondary treatment using activated sludge



(2) The primary agents in the activated sludge process are aerobic bacteria. Also playing an essential role are secondary feeders called holozoic protozoa. Primary bacteria in activated sludge are maintained in the endogenous or declining growth phase. This system allows the primary bacteria to die and lyse, releasing their cell contents to the solution. In doing this, organic matter is continually synthesized by various groups of bacteria. The holozoic protozoa live in a prey or predator relationship, assisting in the continued removal of the bacteria which stimulates further bacterial growth resulting in accelerated extraction of organic matter from solution. In addition, the flocculation (clumping) characteristics of activated sludge are improved by reducing the number of free-floating bacteria in the solution. The better the flocculation characteristics of the sludge, the better the overall rate of sludge settling.

Figure 7-8. Cross-section of a secondary treatment plant using activated sludge treatment



(3) A portion of the sludge volume is continually recirculated from the secondary sedimentation tank or clarifier to the aeration chamber to ensure adequate levels of biological activity are maintained within the tank. In addition, this recirculation process allows for the additional breakdown of organic materials within the sludge.

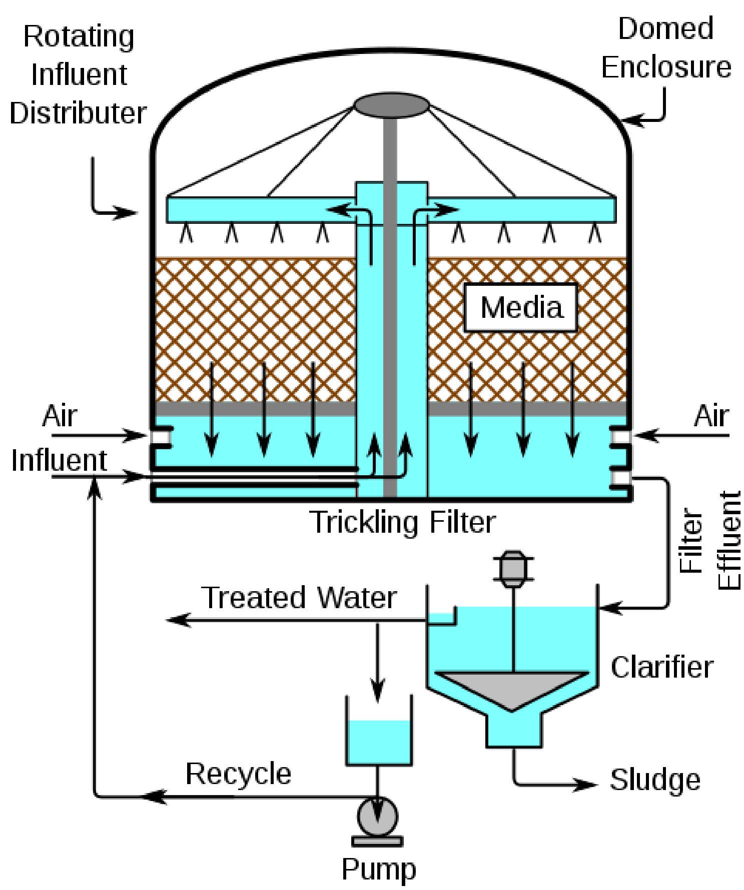
(4) The activated sludge process, under proper conditions, is very efficient, removing 85 to 95 percent of the solids and reducing the BOD the same amount. The efficiency of activated sludge systems is dependent on many factors including climate and characteristics of the wastewater. Toxic industrial wastes can disrupt the biological activity of these systems and wastes heavy in soaps or detergents can cause excessive frothing and thereby create esthetic or

nuisance problems. In areas where industrial and sanitary wastes are combined, industrial wastewater must often be pretreated to remove the toxic industrial chemical components before being subjected to activated sludge treatment.

c. Trickling Filters

(1) The trickling filter (Figure 7-9) is a system designed to achieve BOD reduction through biological action on dissolved organic and finely divided solids. The filter bed (Figure 7-10) is usually of circular construction. Liquid sewage is evenly distributed over the upper surface of the bed by means of rotating arms. The influent is sprayed over the filter bed from a height of about 12 inches to ensure equal distribution over the entire filter bed surface.

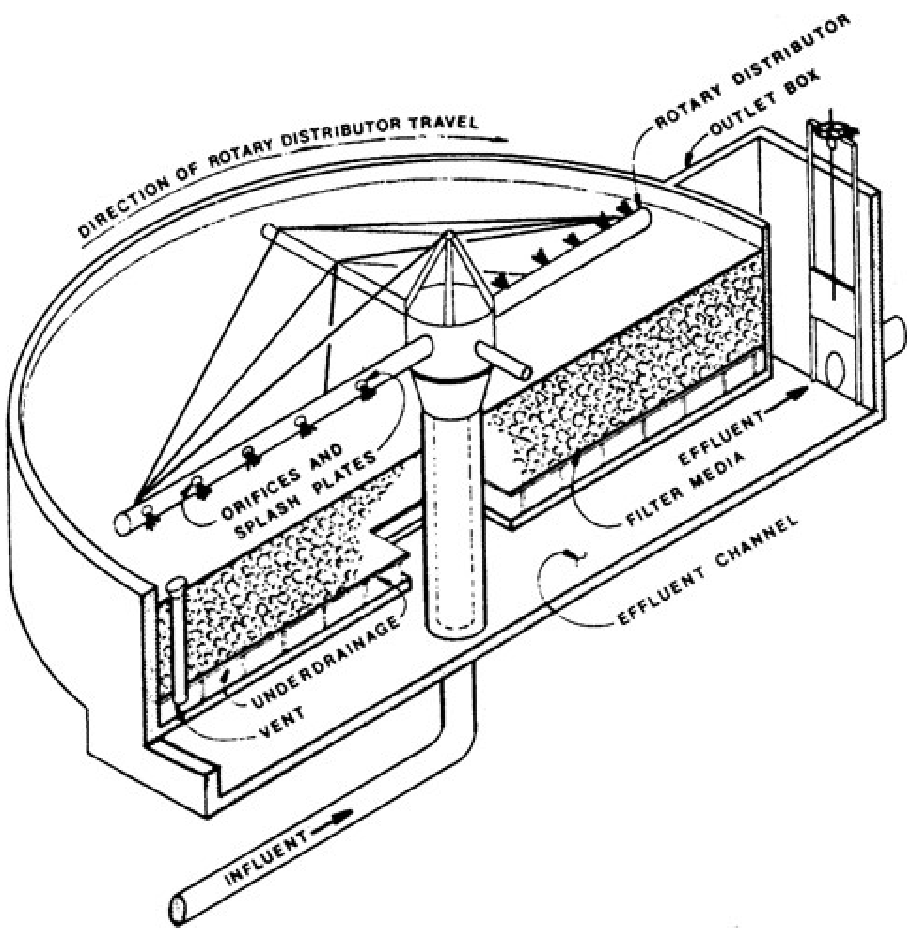
Figure 7-9. Schematic flow diagram of secondary treatment with trickling filter



(2) Filter packing is typically composed of rocks that are 2½ to 4 inches in diameter placed within circular tanks with a depth of 3 to 8 feet. More recent constructions use a plastic packing material and have depths up to 40 feet. The filter bed is constructed with an underdrain system that not only removes the effluent to the secondary sedimentation basins, but allows for free circulation of air throughout the bed to support the growth of aerobic bacteria and other organisms upon which the process depends.

(3) The active portion of the trickling filter system is the biological slime that forms upon the rocks. This film of biological growth is referred to as the zooglea. It consists of layers of bacteria, protozoa, and fungi. In addition, the surface of the bed may support algae growth when temperatures and sunlight are optimal. The lower portion of a deep filter frequently supports the growth of nitrifying bacteria. As the sewage flows down through the filter bed, the suspended and colloidal organic solids remaining after primary treatment are either digested or oxidized as they come into contact with the jelly-like layer of living organisms. As the layer of zooglea builds up, air is not able to penetrate its thickness. Anaerobic bacteria develop between the film and the stone, creating gas which loosens the zooglea which falls free and flows onto the secondary sedimentation basis where it settles and contributes to the formation of sludge. Aerobic bacteria then develop again on the stone surface and the process begins once again. The self-cleaning process makes the trickling filter a very economical and efficient form of treatment. However, this type of system is not readily adaptable where climate conditions include severe winter conditions.

Figure 7-10. Cross-section of trickling filter



(4) Two types of trickling filters currently in use are the standard and high rate. The standard rate trickling filter is dosed intermittently as the raw wastewater enters the plant, while the high-rate filter is dosed continuously. High-rate filtration is accomplished by recirculating a

portion of the liquid from the filter. This process increases the efficiency of the process by preventing the beds from drying out and maintaining the optimum amount of zooglea. Continuous dosing also reduces problems such as fly breeding, freezing, and odors.

(5) As noted in Figure 7-9, wastewater flows from the trickling filter tank into the secondary sedimentation tank, where large volumes of sludge are settled from the wastewater. The effluent is then sent to a chlorine contact tank for disinfection and discharged to a receiving body of water. Sludge is continually removed from both primary and secondary settling basins and processed for disposal.

(6) Filter flies (psychoda) often become a nuisance, but can be controlled by closing the effluent drain and flooding the filter to a depth of 4 inches above the rock surface for 24 hours at weekly or biweekly intervals. To be continually effective, the filter must be flooded at intervals frequent enough to prevent the flies from completing their life cycle between flooding.

d. Stabilization Ponds

(1) Stabilization ponds, also referred to as oxidation ponds or lagoons, are shallow basins used for aerobic and anaerobic degradation of wastewater. They may be employed as the sole treatment process or in combination with other processes such as primary treatment. They are also used for waste storage, equalization of flow and quality, and sedimentation.

(2) Stabilization ponds are constructed as shallow flat bottom ponds enclosed by embankments of earth. Ponds must be lined with compacted clay or other impermeable material to prevent leaching. They can be round, square, or rectangular but should not have a length greater than three times their width. The liquid depth is maintained between 2 and 5 feet with approximately 3 feet of embankment freeboard. The minimum depth of 2 feet is required to prevent the growth of root aquatic plants. Depths of over 5 feet may lead to an odor problem. The size of a stabilization pond is determined by the size of the population it serves and the anticipated BOD load. A rough approximation of anticipated need is 1 acre for every 2,500 persons served by the pond. When a pond size is over 6 acres, it should be divided in segments or cells.

(3) Algal photosynthesis is the key element in the ecology of an aerobic stabilization pond. Aerobic populations of bacteria supply carbon dioxide for algal growth, which is turn supply oxygen to the wastewater which helps to maintain the aerobic balance. Waste organics in the water are metabolized by bacteria. In addition, the pond may contain secondary feeders including protozoa, rotifers, and crustaceans.

(4) If accumulating sludge deposits become too thick, the pond can turn anaerobic and organic constituents would then be digested in the same way as they would in an anaerobic digester. Because of this tendency to become anaerobic, most ponds occasionally emit odors. For this reason, ponds should be located as far as possible from existing or planned development areas. Thought must also be given to the direction of the prevailing winds. In some areas, ponds are mechanically aerated to ensure that aerobic conditions are maintained.

(5) Stabilization ponds are best located in warm, dry climates where large land areas are available. Depending on climate conditions, BOD reduction in a stabilization pond can range from 50 to 90 percent.

7-10. Disinfection

1. Chlorination

a. Chlorine is normally applied to sewage for two reasons: prechlorination for the control of the hydrogen sulfide in sewage; and final chlorination for disinfecting purposes, i.e., to destroy pathogenic bacteria and other undesirable biological life in the effluent.

b. The use of chlorine prior to actual treatment of the wastewater serves two purposes. Since chlorine is an active oxidizing agent, it can breakdown the hydrogen sulfide in the wastewater. This helps to prevent corrosion by reducing the potential of the hydrogen sulfide to mix with water and form sulfuric acid. In addition, odors are eliminated by the removal of hydrogen sulfide. When prechlorination is employed, it is important that an excessive amount of chlorine is not used since the bactericidal action of free residual chlorine may interfere with the biological processes of the secondary treatment system.

c. The bactericidal action of chlorine results from its strong oxidizing power on the bacterial cell's chemical structure, destroying the enzymatic processes required for life. Disinfection of wastewater is defined as the addition of sufficient chlorine so that a free chlorine residual of between 0.5 ppm and 0.7 ppm exists after a 30-minute contact time. The amount of chlorine required to maintain the residual varies greatly depending upon the composition, temperature, and flow rate of the wastewater. Frequent monitoring and adjustment of chlorine flow is needed to maintain uniform results.

2. Other chemicals are occasionally used as disinfecting agents in wastewater treatment processes. These include bromine, iodine, and ozone. However, these chemicals are more often used in swimming pools, spas, and for drinking water treatment. Chlorine is still the most effective way of disinfecting domestic wastewater.

7-11. Advanced Wastewater Treatment (AWT)

1. General

a. AWT refers to processes and methods that are designed to remove more contaminants from wastewater than are usually removed by conventional treatment operations. The term tertiary treatment is often used when discussing AWT, but the two are not precisely the same in meaning. Tertiary suggests a single additional step in wastewater treatment beyond secondary treatment. Advanced treatment means any process or system not now in common use or a system that may modify or replace one or more steps of conventional treatment. An example of this would be the addition of chemicals in a conventional activated sludge process to precipitate phosphorus.

b. As stricter water quality requirements are placed on wastewater treatment facilities, advanced processes for wastewater treatment are becoming more common. AWT systems are used to remove additional BOD, suspended solids, nitrogen, phosphorus, and pathogenic bacteria. In addition, many facilities that have industrial operations must treat their wastes to remove heavy metals, dissolved solids, color, or specific inorganic substances. The technology for performing advanced wastewater treatment is changing rapidly. The basis systems presented here are used with a wide variety of modification and under an equal variety of conditions for advanced wastewater treatment.

2. Chemical Coagulation

a. Chemical coagulation is the process in which a chemical agent is introduced into the wastewater to help remove both organic and inorganic colloidal suspensions in the waste. The colloids found in wastewater consist of discrete particles held in suspension. Their extremely small size prohibits them from precipitating out of solution under normal circumstances. These particles may range in size from 1 to 200 nanometers.

b. There are two types of colloidal suspensions: hydrophilic and hydrophobic. Hydrophilic colloids readily disperse in water. Their lack of tendency to agglomerate depends upon a marked affinity for water. Hydrophilic colloids include soaps, soluble starch, and synthetic detergents. Hydrophobic colloids possess no affinity for water and get stability from their inherent electrical charges. This charge causes repulsion between particles and is referred to as the zeta potential. Metal oxide colloids are examples of hydrophobic solutions.

c. For coagulation to occur, destabilization of the colloidal particles is necessary. Destabilization employs two mechanisms. The addition of electrolytes in solution reduces the net electrical repulsive force at the particle surfaces. Flocculation facilitates bridging between particles.

d. There are two operations involved in the coagulation process. Mixing is the process wherein a dissolved coagulant material is rapidly dispersed with violent agitation throughout the water being treated. Flocculation involves the continuous agitation of wastewater at much slower velocities to allow for the agglomeration of very small particles into well-defined floes that settle readily.

e. The most widely used coagulants for wastewater treatment are aluminum and iron salts. Waters high in organic matter are best treated with aluminum sulfate. Ferric compounds are useful in removing odor problems. Aluminum sulfate and ferric chloride are the coagulants of choice for the chemical coagulation of phosphorus from wastewater.

f. In many cases, coagulant aids are also added to the mixing tanks to adjust the pH of the solution to optimize coagulation. Coagulant aids include activated silica, polyelectrolyte compounds, and clay.

g. Coagulation processes are most often carried out in the secondary sedimentation chamber.

3. Biological Vitrification and Denitrification

a. Biological vitrification is the process by which ammonia nitrogen (NH_3) is converted to nitrate (NO_3). Vitrification does not remove the nitrogen but only changes its form. Removal of the ammonia eliminates the demand for oxygen and the resulting problem of ammonia toxicity. This oxygen requirement is often referred to as the nitrogenous oxygen demand.

b. Two groups of bacteria are responsible for carrying out the vitrification process. They are *Nitrosomonas* and *Nitrobacter,* both of which grow aerobically by obtaining carbon from inorganic sources such as carbon dioxide (CO_2). These nitrifying bacteria are present to some extent in all types of aerobic waste treatment procedures. Their growth rate, however, is very slow when compared to bacteria which are BOD removers. In order "to foster the vitrification process, long detention times are needed (24 hours), the mixed liquor suspended solids concentration must be high, the sludge must be well aged, and wastewater temperature must be maintained above 12°C.

c. Vitrification can be accomplished in one or two stage systems. In a single stage system, BOD reduction and vitrification occur simultaneously during an extended aeration activated sludge process. Two-stage vitrification requires separate aeration chambers for BOD removal and vitrification. This system is most successful for treatment of waste with high ammonia concentrations.

d. In some areas, nitrate can be safely discharged in the effluent. However, if this is not allowable, the denitrification process must be undertaken. Denitrification refers to the biological process of reducing nitrate (NO_3) to nitrite (NO_2) and then to nitrogen gas. This is accomplished under anaerobic conditions by facultative bacteria in the presence of biodegradable organic matter. The nitrate ion serves as an oxidizing agent and is reduced to nitrogen gas in the process.

e. To achieve a satisfactory rate of denitrification, the nitrogen must be in the nitrate (NO_3) or nitrite (NO_2) form; there should be no dissolved oxygen present; and there must be some BOD present to drive the process. Temperature control is essential since the rate of reaction falls off proportionally to a decrease in temperature.

f. Three systems are presently used for the denitrification process. They include anaerobic ponds, anaerobic sludge, and anaerobic filters.

4. Ammonia Stripping

a. Water soluble ammonium ions exist in wastewater solutions in equilibrium with ammonia gas. If the pH of a wastewater solution is raised to a value of 10.5, the equilibrium is shifted in favor of ammonia gas causing it to be formed. In order to accomplish this shift, lime is usually added to wastewater streams to adjust the pH. Ammonia gas may then be removed from the wastewater by stripping with air, as the waste is passed through a slot filled cooling tower equipped with an air blower. The wastewater is allowed to enter the top of the cooling tower at a rate of 1 to 4 gallons per minute per square foot of tower. As the water flows through the packing, air is injected into the system countercurrent to the water. The ammonia gas is subsequently stripped from wastewater.

b. When proper balance between pH, air flow rate, tower depth, temperature, and hydraulic loading is maintained, 90 percent of the ammonia can be removed. After stripping is completed, the pH of the effluent is readjusted to conform to local effluent standards.

5. Filtration and Microscreening

a. Filtration is used for removal of finely divided suspended material after an effluent has been subjected to secondary clarification or chemical precipitation units. In removing the suspended matter, filtration helps to significantly reduce phosphates, COD, and BOD.

b. Filtration can be accomplished by using filter beds made of diatomaceous earth, sand, or mixed media. Wastewater flows through the filter bed where suspended solids are entrapped. After a period of operation, flow through the filter is obstructed by the entrapped material. When this occurs, the filter must be taken offline and backwashes before filtration can continue. If this cleaning is not completed, short-circuiting within the filter bed may occur, resulting in poor effluent quality. Filtration can achieve suspended solid values of 1 to 20 milligrams per liter depending on the efficiency of biological processes that preceded it.

c. A microstrainer can also be used to provide the same results achieved by a filter bed. A microstrainer is a screen in the form of a partially submerged rotating drum. Influent wastewater enters the inside of the drum from one end and flows out through the filtering screen depositing solids on the inner surface of the screen. The screen is continually washed, and the solids are collected and returned to the beginning of the treatment system. Pore size in a microstrainer is between 50 and 60 micrometers. The flow rate is maintained between 5 and 10 gallons per minute per, square foot of submerged screen. One major disadvantage of the microstraining technique is the occasional buildup of grease and biological growth (slime). Extensive and frequent cleaning of mircostraining equipment is required to control these problems.

6. Ion Exchange. Ion exchange is the exchange of one type of electrically charged particle for a different type. A solid material containing exchangeable ions is placed in a bed or column and the wastewater to be treated is then passed through it. Ion exchange systems are used to soften water, selectively remove specific impurities, and recover valuable chemicals lost in industrial waste discharges. Specific applications include the recovery of calcium and magnesium ions from solutions by exchanging them with sodium ions in beds of sodium zeolite, and the removal of ammonia using a natural occurring zeolite material called clinoptilolite. Synthetic organic cation (positively charged ions) exchanges are available for capturing sodium, potassium, calcium, and magnesium ions. Ion exchange beds have a limited capacity. When the number of ions available for exchange are used up, the system or bed must be regenerated; that is, treated to restore the ion exchange capacity.

7. Activated Carbon

a. Activated carbon treatment is used to remove refractory soluble organics not removed by coagulation. These substances include nonbiodegradable organics, color, COD, and odor producing compounds and other organics. Adsorption by means of activated carbon can be accomplished in two ways. Powered carbon can be added to a sedimentation basin where it is mixed, flocculated, and settled from the waste. More frequently, activated carbon columns or counter flow beds are used. Removal of the organics occurs by adsorption of the less polar molecules, filtration of large particles, and deposition of colloidal material. The degree of waste removal is controlled by the length of contact time between the carbon and the water.

b. Carbon used in the activated carbon system is generated by high temperature activation of coal. Activation results in the formation of a network of micropores throughout the carbon which gives it adsorptive characteristics. As the carbon loses its adsorptive and filtering capacity, an increase in the COD of the wastewater is noted. The spent carbon is then regenerated.

c. Carbon removed from a column or bed for regeneration is first dewatered and then placed in a multiple-hearth furnace. The activated carbon is thermally regenerated by heating to a temperature of 1500 to 1700º F where adsorbed impurities are volatilized and released in a gaseous form. Approximately10 percent of the carbon is lost per regeneration cycle.

8. Land Application

a. In some remote areas, wastewaters are disposed of by means of land application. In these projects, wastewaters are run onto grasslands and plowed fields or channeled by means of irrigation systems. These areas are often referred to as sewage farms. The use of wastewater for these purposes provides benefit from the water and the fertilizing components of the waste. When using primary effluent, attempts must be made to limit direct contact with crops. Sewage farms are a rarity in the U.S.

b. In some instances, secondary effluent of high quality can be used for irrigation and spray purposes. The use of water for these purposes is controlled by the effluent standards and disposal criteria established by the State government. Any projects involving land application or reuse of wastewater effluent must be coordinated through NAVFACENGCOM engineering field divisions and BUMED.

7-12. <u>Sludge Digestion and Disposal</u>

1. General. Primary treatment of domestic wastewater creates a sludge which contains approximately 65 percent organic material. The bulk of this sludge is composed of the solids settled from the wastewater. Secondary treatment sludge contains about 90 percent organic material. Advanced wastewater treatment methods create a sludge composed of either a chemical or biological waste, depending upon the composition of the wastewater and the treatment procedure used. Before ultimate disposal of sludge can occur, it must be rendered

innocuous. Therefore, most sludges are subjected to digestion processes prior to terminal disposal. The intention of sludge digestion is to convert the bulky odorous and putrescible waste into a well digested sludge which can be easily dewatered and is relatively odor free.

2. Anaerobic Digestion

a. In an anaerobic digestion process, the organic matter in the waste sludge is decomposed in the absence of molecular oxygen. The end products of anaerobic decomposition are methane gas (CH_4), carbon dioxide (CO_2), unused intermediate organics, and a small amount of cellular protoplasm.

b. There are two main groups of microorganisms responsible for anaerobic digestion. These are bacteria from the acid-forming group and the methane-forming group. The acid-formers convert the complex organic matter to low-molecular weight fatty acids such as acetic, propionic, and butyric acids, also known as volatile acids. The methane forming bacteria convert the volatile acids to methane and carbon dioxide. This is a simultaneous process dependent upon a carefully controlled environment within the digester. Any shift in the delicate balance will result in a decrease of the efficiency of the system. Anaerobic digester failure can result from a sudden increase in organic loading, a sharp decrease in digestive sludge volume, an increase or decrease in the temperature or the presence of an inhibitory substance.

c. Anaerobic digesters are large cylindrical tanks with bottoms sloping toward the center so that the sand, grit, and heavy sludge can be removed. In early construction, digesters were not covered; however, today most digesters have either a floating top (Figure 7-11) or a fixed cover (Figure 7-12). Most digesters are equipped with heaters to help maintain adequate sludge temperatures within the tank.

Figure 7-11. Floating Cover Digester

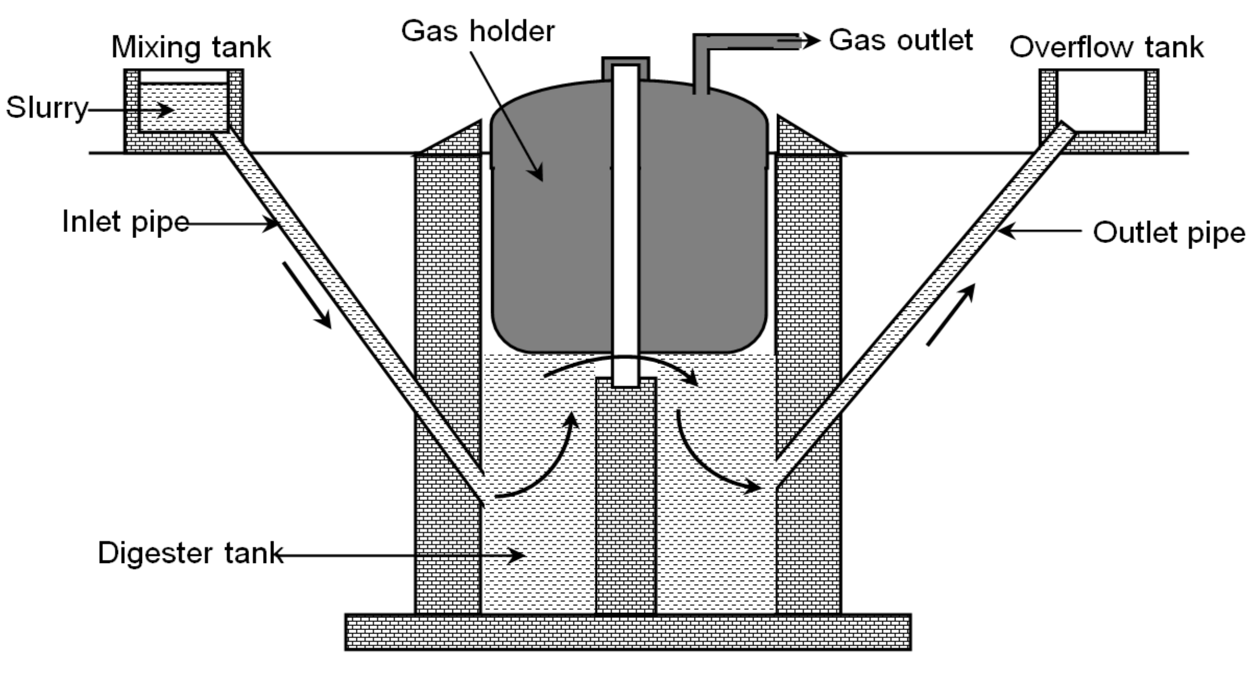
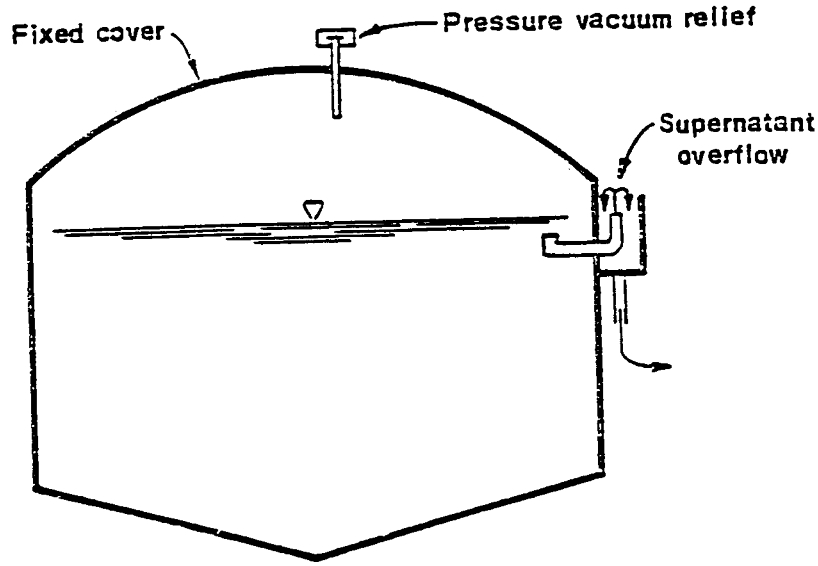


Figure 7-12. Fixed Cover Digester



d. It is most important that air not be allowed into the digester. In a fixed cover system, new sludge must be added to the system every time the finished sludge is drawn off. The floating lid digester moves up and down with the tank level and the gas pressure.

e. The gasification process produces about one cubic foot of the per capita per day. The gas contains approximately 2/3 methane and 1/3 carbon dioxide. In many areas the methane produced by anaerobic digestion is used as fuel for the treatment plant. It can be used to heat the digester or used in the overall plant heating system. Some plants use the methane as incinerator fuel or in internal combustion engines to run pumps and compressors.

f. There are two principal classifications of digesters: conventional (standard rate) and high-rate digesters. The primary difference between the two systems is that the high-rate or two-stage system has a mixing tank or cycle which allows for higher loading rates and continuous feeding and withdrawal of sludge. Detention time in the conventional digester is 30 to 90 days, while the high-rate unit has a detention period of 10 to 20 days.

g. A liquid layer is formed during the digestive process. This layer is referred to as the supernatant. It contains a high concentration of organics and is rich in nitrogen and phosphorus. It must be returned to the wastewater treatment cycle at a point where it will have the least effect.

3. Aerobic Digestion

a. Aerobic digestion is another biological process for treating organic waste sludges prior to terminal disposal. In this system, waste sludge is subjected to extended aeration for a period of 12 to 25 days. During this time, the microorganisms in the sludge break down the organic material. As the supply of nutrients in the sludge decreases, the organisms consume their own cell material and reduce the organic content even further.

b. Aerobic digestion is accomplished in one or more tanks mixed by diffused aeration. Multi-stage systems use the first tanks to accomplish most of the digestion. The last stage is used for solids concentration. A supernatant is produced during this step and must be recycled.

c. The major advantages to aerobic sludge digestion include the production of a more stable sludge, fewer odor problems, and no safety problems related to the production of methane and carbon dioxide. However, aerobic digestion produces a sludge which is difficult to thicken, resulting in disposal problems.

4. Sludge Conditioning, Dewatering, and Final Disposition

a. Sludge handling and disposal is a major part of the wastewater cycle. Even after digestion, sludge handling and disposal is difficult because of the water which is still a major part of the overall sludge volume.

b. Sludges are often conditioned for subsequent dewatering or disposal. Thickening, elutriation, and chemical coagulation are conditioning steps used prior to dewatering.

(1) In the thickening process, the sludge is placed in specifically designed tanks. The sludge is continuously stirred for periods of 6 to 24 hours, during which time the supernatant water is continually drawn off. The continual stirring dislodges gas bubbles, prevents bridging of sludge solids, and keeps the sludge moving toward the center well of the tank. The thickening process usually doubles the sludge concentration.

(2) Elutriation is the process by which a digested sludge is washed prior to further conditioning. The process involves the extraction of alkaline carbonate, phosphates, and fine sludge particles from the sludge. The alkalinity is removed to reduce the amount of coagulant necessary for mechanical dewatering. Elutriation is carried out in tanks similar to sedimentation tanks. Rapid mixing of sludge and wash water is carried out just prior to entering the sedimentation tanks.

(3) Sludge is often chemically treated prior to undergoing the dewatering process. The addition of certain chemicals helps to bring about coagulation of the solids and produces a more rapid release of the water from the sludge. Chemicals used in this process include lime, ferric chloride, ferric sulfate, alum, and organic polymers.

c. Dewatering reduces the moisture content of the sludge so that it can be handled and disposed of in a solid form rather than as a liquid. The three principal methods of dewatering sludge are drying beds, vacuum filtration, and centrifugation.

(1) Sludge drying beds are used where the sewage plant flow is limited, and land is available. The beds are composed of a gravel bed covered with a layer of sand between 6 and 12 inches in depth. A tile underdrain system is often placed under the gravel bed to improve water removal. The bed area is divided into cells of approximately 20 by 50 feet. The sludge is drawn off from the digester and poured into the bed. Sludge is poured to a depth of 8 to 10 inches. The

dewatering of sludge is due to drainage and evaporation. The major portion of sludge drying is accomplished in the first 3 to 5 days. Drying times depend on the initial water content and weather conditions and may range from 1 to 3 weeks. Using sludge beds, it is possible to obtain a sludge water content of approximately 25 percent.

(2) Vacuum filters are used for sludge dewatering at medium to large size treatment plants where large land areas are not available for sludge drying beds. Vacuum filters can also be used to handle raw sludge that has not been digested. The vacuum filter consists of a large drum on which a filter media has been placed. This media can be made of cloth, synthetic fiber, stainless steel mesh or coil springs. The drum rotates so that approximately 1/4 of it is submerged in the sludge. Vacuum pressure applied to the drum causes sludge to cake on the drum surface. As the drum rotates, the water is drawn from the sludge by the vacuum. The dewatered sludge is then scraped off the filter and collected in a hopper. Moisture content of the dewatered sludge is approximately 60-75 percent.

(3) Treatment plants handling large volumes of waste material may use a centrifuge for dewatering sludge. Centrifuges separate solids from the liquid by sedimentation and centrifugal force. Sludge for centrifugation is usually chemically conditioned prior to being dewatered. The sludge produced in the use of the centrifuge has a water content of between 65 and 75 percent.

d. After the solids produced in wastewater treatment operations are stabilized and reduce in volume, the problem of terminal disposal remains. The only acceptable disposal alternative is disposal on land.

e. Sludge lagoons are a long-term method of storing sludge and are used where there is a large land area available. Lagoons are natural or artificial basins with an average depth of 4 to 10 feet that are lined with clay or other impermeable material. Digested sludge, when placed in a lagoon, will continue to dewater by means of evaporation. Liquid that settles to the bottom of the beds must be collected by a leachate control system and transported off site for further treatment or disposal. After lagoons have filled up and the sludge has completely dried, the lagoon can be dug out and the sludge residue used for fill. Sludge which has been poorly digested may create an odor problem.

f. Sludge that has been dried on beds can be successfully disposed of on land. In some areas, liquid sludge that has not been digested is poured directly onto the ground from tank trucks. This can be very beneficial to the soil; however, one must be made aware of the possible health hazards. Raw sludge must be carefully monitored since this sludge may contain considerable quantities of disease producing organisms. It should not be used as a general soil conditioner or fertilizer if people are to be in contact with it. The area that has raw sludge disposed on it should not be used for root crops or low growing vegetables that may be eaten raw. Particular attention should also be given to ground water and surface water runoff. Special care and attention should be given to sludge containing high concentrations of heavy metals. These types of sludge wastes must not be disposed of in an agriculture setting.

g. Disposal of dewatered sludge in a properly run sanitary landfill is one of the best disposal methods available. Since the sludge is buried and covered with a layer of soil, nuisance conditions are kept to a minimum.

7-13. Industrial Wastewater Treatment and Disposal

1. The character of industrial wastewater varies as widely as industrial processes. Industrial wastes include organic chemicals, such as phenols and chlorinated hydrocarbons; corrosive wastes, including acids and alkalines; toxic chemicals, such as cyanide and heavy metals; greases and oils; radioactive wastes, thermal pollution, and many others. Many of these industrial wastes can be very disruptive to domestic wastewater treatment systems by inhibiting or otherwise interfering with the treatment processes and causing major sludge handling and disposal problems. In addition, these wastewaters can adversely affect the quality of the receiving waters into which they are discharged.

2. Problems concerning the treatment and disposal of industrial wastewaters at Navy and Marine Corps facilities must be brought to the attention of the public works officer or the responsible NAVFACENGCOM engineering field division.

7-14. Health Precautions for Wastewater Treatment System Personnel

1. This article provides information regarding health precautions and other preventive measures recommended for personnel who work with wastewater treatment systems.

2. Those personnel who are in contact with wastewater, or who work in or inspect wastewater treatment plants, must keep their basic immunizations current. Immunizations required include polio, tetanus, and diphtheria.

3. Wastewater treatment plant personnel must not eat, drink, or smoke when performing maintenance on or inspecting equipment which may be a direct source of contamination.

4. In the event of a significant wastewater spill, those cleaning the area must wear coveralls, rubber boots, rubber gloves, hair coverings, and face shields. Upon completion of spill clean-up, contaminated clothing must be removed and placed in a plastic bag for laundering. Clean-up personnel must take a hot shower, using plenty of soap and water, promptly after spill clean-up is completed. Caution must be exercised when cleaning sewage spills in confined spaces. The gases given off by sewage can be explosive, toxic, and displace the oxygen in the space.

5. Following containment, appropriate handling, and management of waste and clean-up materials, clean-up of wastewater spills may be accomplished using detergent and water, followed by thorough rinsing. Disinfection of the spill area is required in food service, berthing, and medical spaces. Disinfection may also be helpful in preventing odors in other areas. Recommended disinfectants are listed in article 7-20.

6. In the event of a major leak or spill, the cognizant medical department must be notified.

7-15. Medical Department Responsibilities

1. Cognizant medical department representatives must periodically inspect wastewater treatment facilities to detect potential health hazards to operators and members of the surrounding community.

2. Medical department representatives must be alert to any increase in disease incidence among treatment plant operators or members of the surrounding community which may be attributed to exposure to human waste. See Appendix A.

CHAPTER 7
WASTEWATER TREATMENT AND DISPOSAL ASHORE AND AFLOAT

SECTION III. WASTEWATER TREATMENT AND DISPOSAL AFLOAT

7-16. Introduction

1. The overboard discharge of untreated sewage within the navigable waters of the U.S. and territorial seas (within 3 nautical miles of shore) is prohibited. Navy vessels are equipped with marine sanitation devices (MSDs) which either treat sewage before discharge, or collect and hold it until it can be properly disposed of through dockside sewer connections or pumped overboard in unrestricted waters.

2. MSDs on Navy ships increase the potential for contamination of berthing and working spaces with raw sewage. Therefore, the Medical Department Representative (MDR) must be familiar with the sewage disposal system and the procedures necessary to ensure the health and safety of the ship's crew. MDR should consult with the chief engineer and the afloat environmental protection coordinator (AEPC) for details on the system installed onboard the vessel.

3. There are two different types of MSDs on USS Navy vessels, Type III-B MSDs include collection, holding, and transfer (CHT) systems (Figures 7-13 and 7-14) and vacuum collection, holding and transfer (VCHT) systems (Figure 7-15).

a. CHT systems are a zero-discharge system within restricted waters and uses a standard 3-5 gallons/flush for toilets (water closets) and 0.8 – 1 gallon/flush for urinals. CHT systems hold sewage in holding tanks until it can be properly discharged (Figures 7-13 and 7-14). CG 47 Class, CVN 68 through CVN 76, LHD 1, LHA 6 and LSD 41/47 Class ships have CHT systems.

b. VCHT systems are a zero-discharge system within restricted waters and uses 3 pints/flush for toilets and 1 pint/flush for urinals. VCHT system collects or stores sewage from toilets and urinals until it can be properly discharged over the side or otherwise disposed of through pierside facilities (Figure 7-15). They differ from CHT systems in that they minimize the volume of wastewater using a controlled volume vacuum flush system. CVN 77, CVN 78 Class, DDG 51 Class, LPD 17 Class, and LCS 1 and LCS 2 variants use VCHT systems.

c. Type II MSDs collect sewage from toilets and urinals using a VCHT system, but then process the wastewater to meet environmental regulations prior to discharge. The vessel is allowed to discharge treated sewage within 3 nm of the nearest land unless within an EPA no-discharge zone.

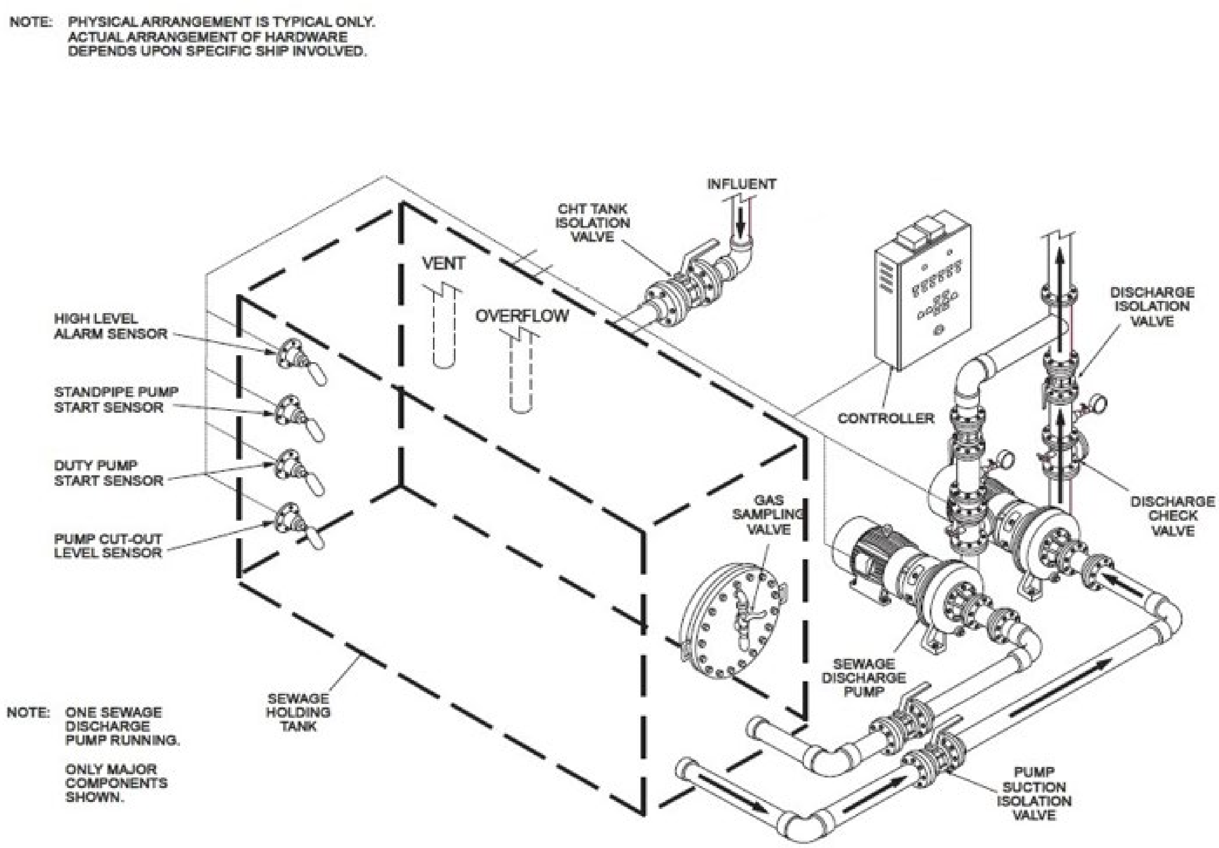
7-17. Marine Sanitation Device Systems Descriptions

1. Collection, Holding, and Transfer System

a. CHT systems have been installed on most Navy ships. The systems are designed to operate in three modes:

(1) transit mode (restricted waters), sewage is collected and retained in holding tanks while graywater is discharged overboard via diverter valves.

Figure 7-13. CHT System



CHT System

(2) at-sea mode, all sewage and graywater, including any retained in the holding tanks, is diverted or discharged overboard; and

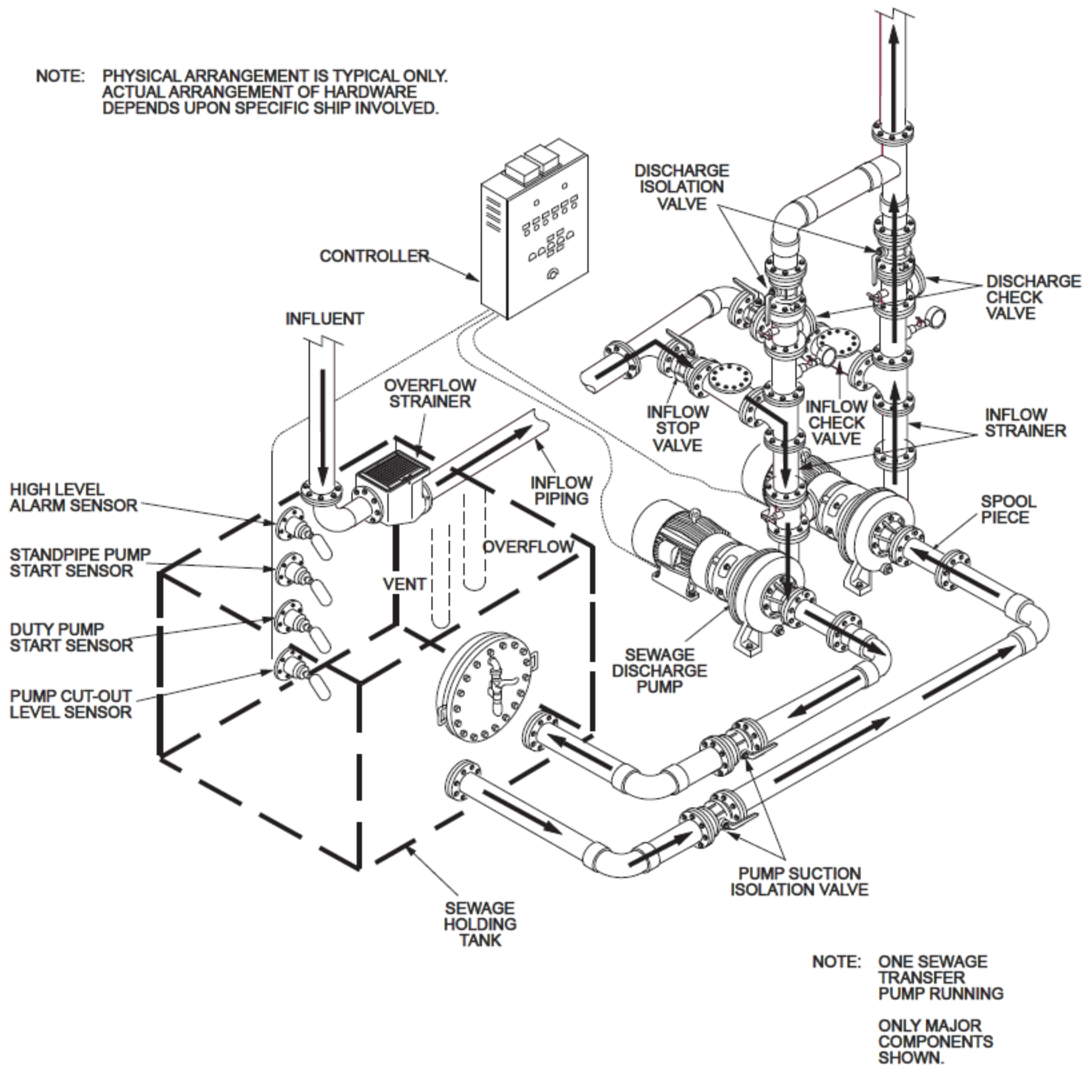
(3) in-port mode, sewage and graywater are collected in holding tanks and discharged into a shore sanitary sewer or ship waste off-load barge (SWOB).

b. The CHT system is composed of three functional elements:

(1) The collection element consisting of soil drains (from toilets and urinals), graywater drains (from showers, laundries, and galleys) and diverter valves which direct the wastewater over the side or to the holding tanks.

(2) The holding element, consisting of tanks, retains sewage during transit of restricted waters for eventual disposal. These tanks are normally sized for a 12-hour holding period depending on individual ship constraints. Holding tanks of 2,000 gallon, (Figure 7-13), capacity and over are designed with an aeration system to prevent sludge from settling and becoming anaerobic. Smaller tanks (less than 2,000 gallons), (Figure 7-14), do not require aeration and may incorporate strainers (some CG 47 ships only), which prevent large solids from entering the holding tanks.

Figure 7-14. Strainer-type CHT system



(3) The transfer element includes sewage pumps, overboard and deck connection discharge piping and associated diverter valves and check valves. Each tank is equipped with two sewage pumps which are connected in parallel to discharge sewage or graywater to a receiving facility, SWOB, or directly overboard.

c. The CHT system can be operated in a manual mode in which the pumps are actuated independent of the level of wastewater in the holding tanks or in a fully automatic mode. When operating in a manual mode, an option is available which will deactivate the pumps automatically when the low liquid level of the tanks reaches approximately 10 percent of the tank volume to maintain pump suction. In the fully automatic mode, these functions are accomplished:

(1) Duty pump alternation.

(2) The low liquid level stops the pump when the level reaches approximately 10 percent of its capacity to keep the pumps primed.

(3) At 30 percent liquid level, a sensor signals the duty pump to activate.

(4) At 60 percent liquid level, a sensor signals the standby pump to activate.

(5) At approximately 80 percent liquid level, a visual and audible high-level alarm is activated.

d. Variations of the functional liquid level set points exist and are documented in each shipboard operational sequencing system and maintenance procedures (i.e., aircraft carrier CHT, graywater and ground food waste collection tank level control system).

2. Vacuum Collection, Holding, and Transfer (VCHT) System (Figure 7-15)

a. A VCHT system is a Type III-B MSD designed to collect sewage by means of vacuum while in port; to offload sewage to suitable shore receiving facilities; to hold sewage while transiting within 0-3 nm; and to discharge sewage overboard while operating beyond 3 nm.

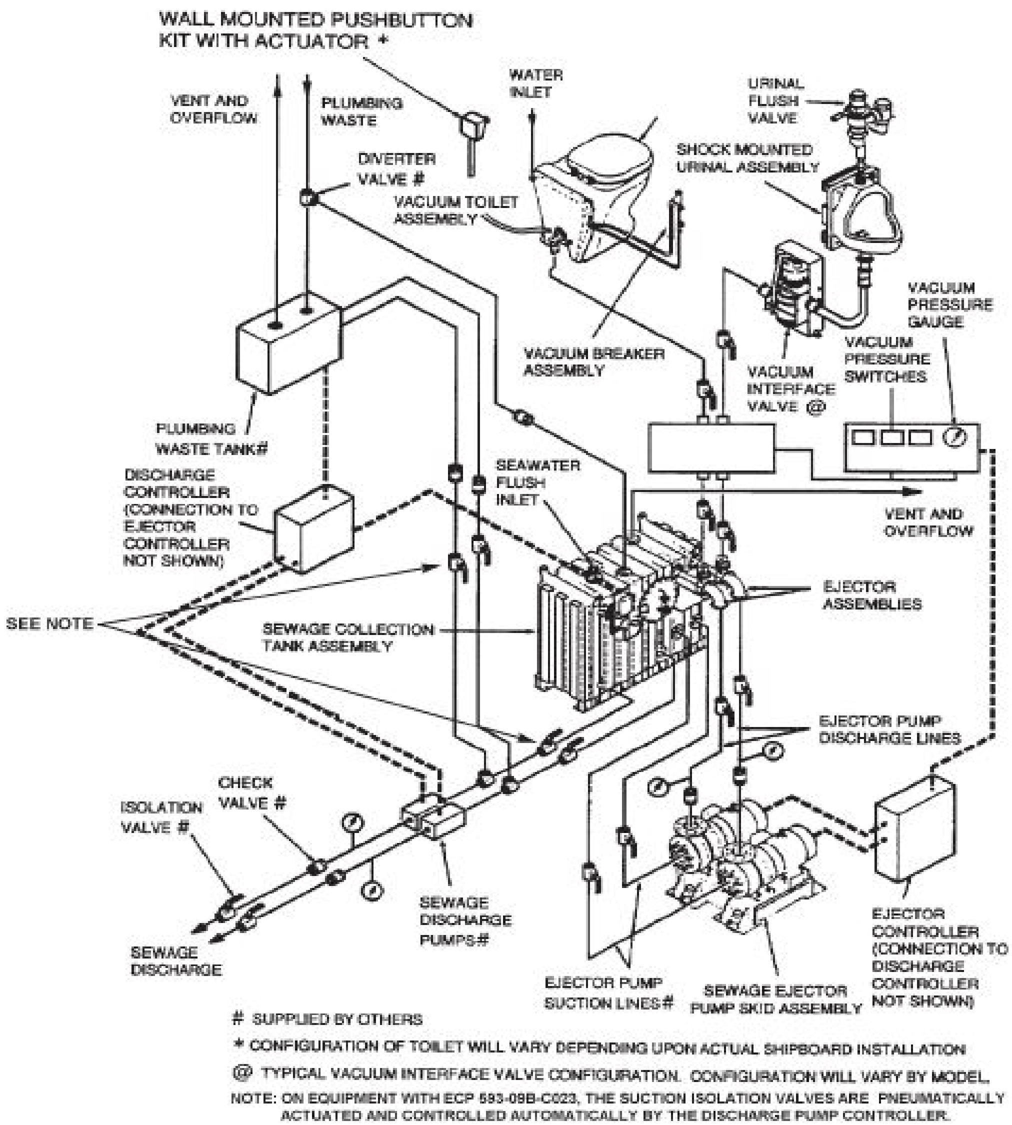
b. The VCHT system is composed of three functional elements:

(1) Vacuum Collection Element. On most VCHT systems sewage is collected in the vacuum collection (VC) piping (from toilets) by recirculating sewage from the holding tank through vacuum ejectors (nozzle and non-return valve) connected to a vacuum manifold. As sewage is recirculated through the ejector pump suction and discharged through the ejector nozzle, there is a sudden drop in pressure, which opens the non-return valve. The ejector assemblies are connected to the vacuum manifold and suction from the manifold and the VC piping is created when the non-return valve is opened, which draws sewage from the VC piping and vacuum manifold and discharges it through the ejector in to the VCHT holding tank.

(2) Holding Element. The VCHT system includes a holding tank to hold sewage until pumped overboard or to a shoreside facility. In the fire main powered eductor system, the holding tank is under vacuum. In the sewage powered ejector and on-line systems, the tank is not under vacuum. Atmospheric VCHT tanks have some common features with CHT tanks. On most ships, a fire main connection is provided for flushing and cleaning the VCHT holding tank. Seawater can be delivered to the holding tank through washdown nozzles, which spray the inside of the holding tank.

(3) Transfer Element. Most ships equipped with VCHT systems are typically equipped with a transfer system similar in design and operation to the transfer element of a CHT system. In many cases, unlike CHT systems, macerator pumps are used to transfer sewage from VCHT systems.

Figure 7-15. Typical VCHT System (DDG-52)



c. Automatic Mode (AUTO) - When the discharge pump selector switch is set to BOTH, and the discharge pump selector switches are set to AUTO, the pump controller performs three functions as a result of signals generated by the level sensors in the plumbing waste (PW) and VCHT tanks. For example, DDG-52 and follow VCHT system automatic operation is as listed:

(1) The pump stop level sensor signals the controller to stop the duty discharge pump(s) when the liquid level in the holding tank reduces to a pre-determined level (15 percent of PW tank collection capacity and 56 percent of VCHT tank holding capacity).

(2) The pump start level sensor signals the controller to start the duty pump(s) when the liquid rises to a predetermined level (75 percent capacity for the VCHT and PW tanks).

(3) The high-level alarm level sensor (90 percent capacity for the VCHT and PW tanks) signals the controller to provide a visual and audible high level alarm signal in the pump space and in a continuously manned, remote location. The discharge pump controller will signal the ejector controller to stop ejector operation until the VCHT tank high level alarm clears.

(4) Vacuum Generation Controls and Alarms. There are several types of pump control configurations based on the VCHT system installed. The table shown here provides information on various configurations in the Fleet:

Vacuum pressure switches, transducers, micro-switch settings.

Ship/Ship Class	Signal devices	Settings
CVN 77/CVN 78	Two vacuum pressure transducers	18 in Hg., 14 in Hg., 12 in Hg., 11 in Hg., 10 in
DDG 52AF	Three vacuum pressure switches	18 in Hg., 14 in Hg., 12 in Hg.
DDG 113AF	Two vacuum pressure transducers	18 in Hg., 14 in Hg., 12 in Hg.
DDG 1000	Two vacuum pressure transducers	18 in Hg., 14 in Hg., 12 in Hg.
LCS 1	One transducer	18 in Hg., 14 in Hg., 12 in Hg.
LCS 2	Two vacuum pressure switches	16.5 in Hg., 12.4 in Hg., 11.8 in Hg.
LPD 17 Class	Four vacuum pressure switches	18 in Hg., 15 in Hg., 13 in Hg., 11 in Hg.

Table 7-2 - Fleet Vacuum Generation Controls and Alarms Configurations

3. DDG-52AF class ejector pump controls are described in article 7-17, subparagraph 3a(1) through 3a(2) as an example:

a. DDG-52AF ejector pump controls

(1) Manual Mode (MAN) - Placing either pump selector switch in the MAN position allows the operator to override the vacuum pressure switches and manually operate the ejector pumps independently or together.

(2) Automatic Mode (AUTO) - When both pump selector switches are in the AUTO position, the controller will alternate ejector pump operation to ensure even wear and allow for control of the pump by the vacuum pressure switches. When the system vacuum drops below 14 in Hg., one switch signals the ejector pump controller to activate the duty ejector pump. When

the system vacuum drops below 12 in Hg, a second switch signals the ejector pump controller to activate the standby ejector pump. Finally, a third switch signals the ejector pump controller to secure both pumps at the maximum operating vacuum level of 18 in Hg. At 90 percent VCHT tank liquid high level, a level sensor (or liquid level switch) in the tank signals the ejector pump controller to de-activate ejector pumps preventing further sewage collection.

b. Variations of the functional liquid level set points and automation are documented in each shipboard operational sequencing system and maintenance procedures. MDR should consult with chief engineer and operator(s) for detailed description of the installed MSD.

7-18. Inspection of Marine Sanitation Device

1. The guidance on inspecting MSD components provided in this article is to support routine habitability and sanitation inspection program by MDRs. Engineering personnel responsible for the MSD and associated subsystems should be consulted prior to and during the inspection. Appendix B provides a general form to support the visual inspection and Appendix C is to support the system inspection.

2. Labeling and Color Coding

a. On the interior of the ship, MSD valve handles and operating levers (excluding handwheels of gauge valves located on gauge boards) must be color coded gold for sewage and striped gold and light purple for graywater per NSTM Chapter 505. Sewage, ground food waste, and plumbing waste piping must be stenciled for service and direction of flow per NSTM Chapter 505. Exterior deck discharge stations must be painted the same color as the surrounding structure.

b. Deck discharge stations must be clearly labeled to include hose handling procedures and sanitary health precautions as described in NSTM Chapter 593.

3. MSD components must be regularly inspected for leaks by appropriate engineering personnel responsible for the compartment in which the MSD components are located. Inspection of MSD components are accomplished per established procedures approved by NAVSEASYSCOM such as, integrated class maintenance plans, Planned Maintenance System (PMS), and NSTM Chapters 593 and 505.

These inspections should include:

a. Soil and waste drains, discharge lines, flanges, joints, access plates, and clean out plugs.

b. Gate and ball valves.

c. Plug valves.

d. Automatic pump starters.

e. Sewage pumps, including housings and seals.

f. Tank penetrations and manholes.

g. Air compressors.

h. Drip pans.

i. When operating in "port" mode, include sewage transfer hoses and riser connections.

4. The "paper towel" test can be used to pinpoint small leaks from pumps and pressurized sections of the piping system. This test entails opening a paper towel and holding it suspended 2 to 3 inches from the units for several minutes while they are operating. The source of even the finest spray can be detected by the paper towel becoming spotted or wet.

5. All temporary pipe repairs must follow NSTM Chapters 505 and 593 and documented (logged) in the repair division's Consolidated Ship Maintenance Plan accompanied by a job sequence number (JSN) indicated on a tag attached to the repaired piping per the ship's maintenance and repair log.

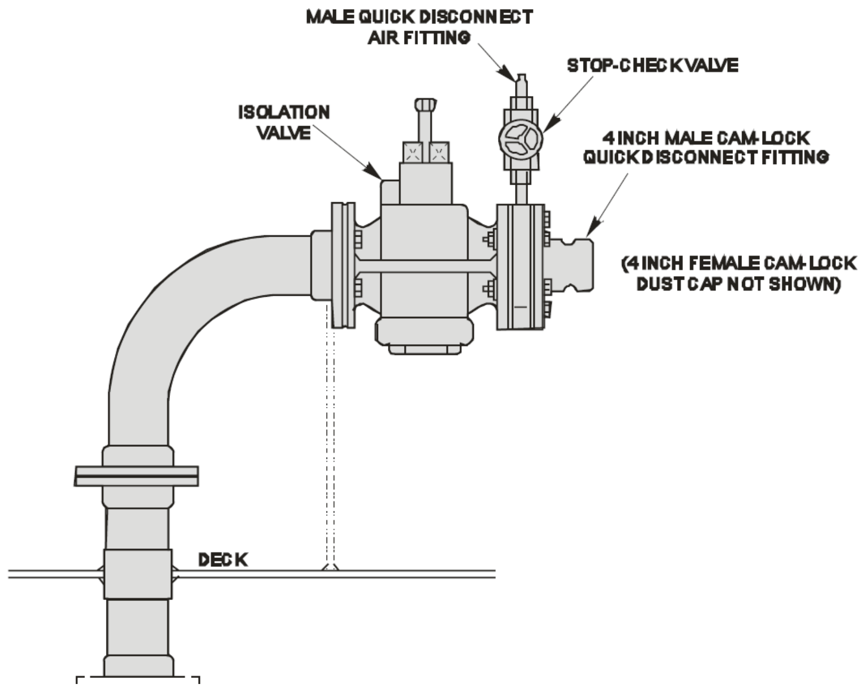
6. The ventilation system installed in the MSD room must be operational and, if installed, have alarms associated with low-flow ventilation or H2S monitors in the MSD room. The space sump within the MSD room (if present) must be checked for sewage accumulation.

7. All leaks, spills, or other sources of contamination observed during these inspections or at any time must be promptly reported to the executive officer, engineering officer, damage control officer, and the senior medical department representative. Appropriate action must be taken to arrest the leak and properly clean and, when appropriate, disinfect the contaminated area as described in article 7-20.

7-19. <u>Ship to Shore Sewage Transfer</u>

1. Sewage receiving facilities have been constructed at most shore activities with fleet support capability. These facilities include sewer risers located along all piers and quay walls for the transfer of sewage from the ship discharge risers to the shore sewer system. Also included are facilities to store, maintain, and repair sewage transfer hoses. Specific information and guidelines concerning all aspects of ship to shore sewage transfer facilities and procedures are provided in NAVFAC Publication MO-340, Ship-to-Shore Hose Handling Operations Manual.

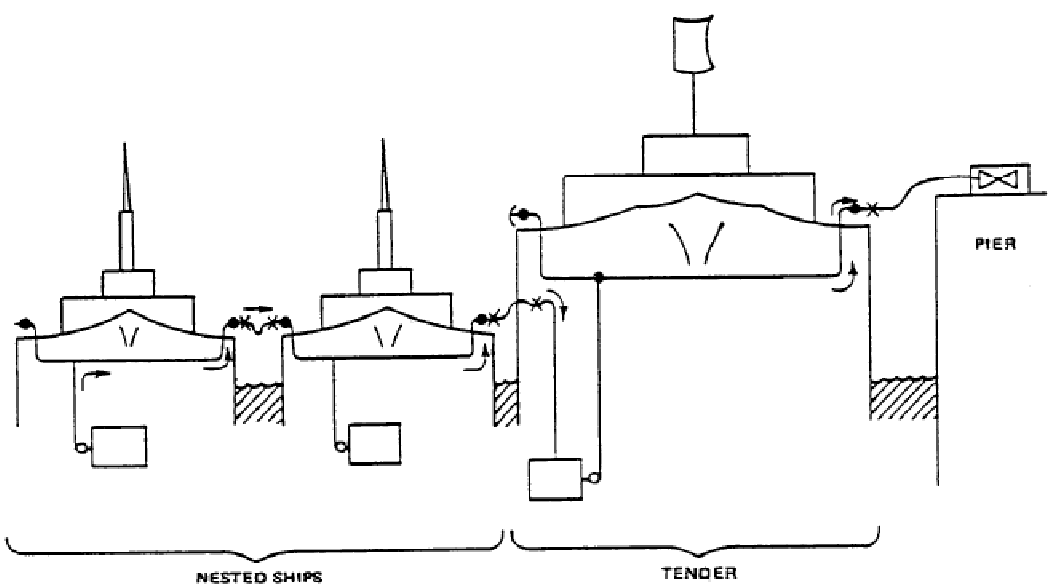
Figure 7-16. Sewage discharge shore connection



Note: A watertight containment coaming surrounding all components is not shown.

2. Navy MSDs are designed to discharge sewage to a shore receiving facility or a SWOB when in port. This may be accomplished directly by connecting the ship's sewage discharge risers to the pier sewer risers, or indirectly by connecting to a SWOB or another ship's system which in turn discharges the sewage into pier risers (Figure 7-16).

Figure 7-17. Nested Ship Sewage Transfer



3. Ship-to-ship sewage connections (Figure 7-17) occur when several ships are nested at one pier, berth, or when a vessel is nested to a tender. Ships with CHT systems have athwartship piping which allows them to receive sewage from an adjacent ship and transfer it to another ship with the same capability. Thus, several ships' CHT systems can be connected in series such that the sewage generated on these ships, is conveyed through the inboard ships' systems to the pier risers. Vessels with other than CHT systems do not have the pump-through capability and must be connected directly to a pier, SWOB, or a ship such as a tender which has pump-through capability.

4. Most sewage connections, including ship-to-shore and ship-to-ship, are made by means of 50-foot length, 4-inch flexible rubber or plastic sewage transfer hoses which are provided by the sewage receiving facility. The only exceptions are submarines which use a 50-foot length, 2½ inch rubber hose. When a ship arrives for berthing, a shore-based handling crew delivers the proper amount of clean sewage transfer hoses to the pier and connects the hoses to the pier risers. The ship's crew is responsible for connecting transfer hoses to the ship's risers on ship-to-shore and ship-to-ship connections per Sewage Disposal Operating Sequencing System (SDOSS) procedures and posted placards.

5. Sewage transfer hoses must be kept clean and in good repair to avoid unsanitary conditions. Prior to returning the hoses to storage after use, they must be cleaned of residual wastewater per SDOSS and posted placards. This is usually accomplished by flushing the hoses for at least 10 minutes prior to disconnection with high pressure salt water which is admitted into the MSD discharge piping from the ship's firefighting system. When a vessel does not have this capability, the shore crew must flush the hoses by connecting them to the nearest saltwater pier riser. In addition, hose couplings and exterior surfaces must be cleaned, and the ends of the hoses capped prior to storage. Sewage transfer hoses must never be used for potable water connections and personnel handling sewage transfer hoses must not subsequently handle potable water hoses or connections until appropriate cleaning measures have occurred, per article 7-20, subparagraphs 3a through 3d.

6. In the event wastewater is spilled onto the deck of the ship or onto the pier, the affected area must be immediately cleaned per NSTM Chapter 593 and posted placards. Approved disinfectants and personal protective equipment (PPE) are stocked and available in the sewage spill locker. A list of cleaning gear and PPE is posted on the locker per NSTM Chapter 593. Disinfectant germicidal fungicidal concentrate (phenolic type) may be used to prevent or eliminate strong odors caused by the wastewater spill (Disinfectants; Betadine Surgical Soap, NSN 6505-00-994-7224, Wescodyne (CID A-A-1440), NSN 6840-00-782-2691, Povidone-Iodine Solution, NSN 6505-00-914-3593).

7. Sewage hose handling and storage facilities are designed to accommodate the repair, maintenance, and storage of sewage transfer hoses. Hose handling and storage facilities are required to incorporate the design features to preclude conditions which could cause accidents or communicable diseases in article 7-19, subparagraphs 7a through 7h:

a. Racks and tables used for the handling and storage of sewage transfer hoses must be constructed of metal or other impervious material. Wooden racks and tables are prohibited.

b. All windows and doors which open to the outside must be adequately screened to prevent the entry of flying insects.

c. Back siphonage prevention devices must be installed on all potable water lines used for flushing and cleaning sewage transfer hoses.

d. Lavatories and showers with hot and cold running water, soap, and single use towels must be provided.

e. Sufficient ventilation must be provided in all indoor workspaces.

f. Incandescent and fluorescent lights must be protected from breakage, and nonslip surfaces must be installed on the deck in the hose washing areas.

g. Disinfection of sewage transfer hoses is not normally required; however, the hose handling facility should have this capability in the event the need arises.

h. The sewage hose handling and storage facility must be constructed, equipped, and operated in conformance with appropriate health and safety requirements promulgated by the Occupational Safety and Health Administration (OSHA).

7-20. <u>Personal Hygiene, Sanitation, and Safety</u>

1. Strict adherence to good personal hygiene and sanitary practices is essential to prevent the spread of fecal contamination and resulting potential for the occurrence of communicable diseases.

2. Personnel are required to wear protective clothing including coveralls, rubber boots, rubber gloves, face shields, hair covering, and an oxygen breathing apparatus (OBA) as appropriate when contact with sewage is likely during maintenance, or spill clean-up operations. Approved disinfectants and PPE are stocked and available in the sewage spill locker near or in the MSD pump room. A list of cleaning gear and PPE is posted on the locker per NSTM Chapter 593.

3. Personnel who come in contact with sewage in the course of their duties, or as the result of a sewage spill or system backflow must adhere to the requirements in article 7-20, subparagraphs 3a through 3d to minimize the spread of contamination to other areas of the ship.

a. Movement about the ship wearing contaminated clothing must be kept to an absolute minimum.

b. Contaminated clothing must be placed in a plastic bag at the conclusion of maintenance or spill clean-up operations for laundering in hot water and detergent. No special laundering procedures are required.

c. Rubber boots, gloves, OBA, and other similar items must be washed with hot soapy water, rinsed with hot clean water, and treated with an approved disinfectant solution.

d. Personnel must thoroughly wash with soap and water before engaging in other activities. In the event of a sewage spill, all sanitary and safety requirements specified in NSTM Chapter 593 must be strictly followed.

4. Spaces which become contaminated with sewage as a result of leaks, spills, or sewage system backflow must be thoroughly washed down with water and a stock detergent. In addition, food service spaces berthing areas, and medical spaces must be treated with an approved disinfectant (EPA registered and labeled) such as NSN 6840- 00-753-4797, Disinfectant, Germicidal Fungicidal Concentrate (Phenolic Type) or NSN 6840-00-526-1129, Disinfectant, Germicidal and Fungicidal Concentrate (Iodine Type). To be effective, these agents must be used per instructions printed on their respective labels.

5. Bilges contaminated with sewage wastes must be pumped out, washed down with a fire hose, and pumped out again. If potable water tanks form the floor of the bilge, daily bacteriological monitoring of the water from those tanks must be promptly initiated and continued until it is assured that sewage contamination of the tanks has not occurred. Furthermore, if the potable water system is suspected of being contaminated, the appropriate tanks must be secured until the water is determined to be safe.

6. Signs must be posted in spaces containing MSD equipment warning maintenance personnel against consuming food and beverages or smoking in MSD spaces and directing them to thoroughly wash with soap and water prior to leaving the area.

7. Personnel who handle or connect sewage transfer hoses must not subsequently handle potable water hoses without first washing and changing into clean clothing.

8. There must be no open flames, flashlights, or other electrical apparatus in or near open holding tanks or other voids until they have been certified safe by a gas-free engineer. When the tank is designated gas free and safe, personnel may enter using an OBA or other approved respiratory protection device specified in NSTM Chapter 593. A safety harness and tending line must be used if only a single person enters the tank. If more than one person enters the tank, they must keep in constant sight of one another. Personnel must always be on hand outside the tank to watch those inside and the ready to lend assistance. See articles 7-22 and 7-23 for additional health and safety provisions.

7-21. Medical Department Responsibilities

1. The presence of marine sanitation devices and the associated equipment and facilities aboard ship increase the risk of exposure to untreated wastewater which in turn increases the potential for the occurrence of infectious diseases associated with human waste. Since preventive medicine is an integral part of the medical department responsibility aboard ship, it is incumbent upon the MDRs to become familiar with the MSD system aboard their ship; knowledgeable in the proper personal hygiene practices and decontamination procedures regarding the operation and maintenance of MSD systems; and to take an active role to ensure the systems are operated and maintained in a safe and sanitary manner.

2. The MDR's duties must include:

a. Conduct visual inspections of MSD components as described in article 7-18 as part of the routine habitability and sanitation inspection program or on a more frequent basis as the situation dictates. Whenever practicable, inspections should be conducted in conjunction with engineering department personnel.

b. Indoctrinate personnel associated with the operation, maintenance, and repair of MSD systems concerning the potential health hazards associated with human wastes, proper personal hygiene necessary to reduce the risks associated with working with MSD systems, and the correct procedures for cleaning and disinfecting contaminated spaces. This training must be conducted on a periodic basis to ensure the appropriate personnel are able to operate and repair the MSD system without endangering themselves or the ship's crew.

c. Provide on-site advice, when requested, in the correct procedures for personal protection and disinfection of spaces in the event of major sewage leaks or spills. The MDR must be present for clean-ups and disinfection of food services spaces, living areas, and medical spaces.

7-22. Safety and Health Hazards of Sewage, Plumbing Waste, and Food Waste Systems

Note: Consult with chief engineer, repair division, damage control, and the ship's afloat environmental protection coordinator. Refer to NSTM Chapter 593.

1. A serious potential hazard associated with MSD systems is that toxic or explosive gases could be released in confined spaces. Hydrogen sulfide has been identified as the most likely gas hazard associated with the decomposition of sewage in MSD tanks, however, other gases may include methane, ammonia, and carbon dioxide.

2. The precautions in article 7-22, subparagraphs 2a through 2e will minimize the potential hazards resulting from the release of toxic gases.

a. Ensure the installed MSD tank aeration system is operated properly in tanks larger than 2,000 gallons. The aeration system must be operated while transiting the 3-mile zone or while in port as sanitary wastes are being collected. Systems with tank capacities of less than 2,000 gallons do not have aeration systems; but because of the smaller tank capacity, the discharge pumps will cycle more often while in port.

b. Always assume the MSD tank contains sewage and toxic gases. Any maintenance requiring the removal or disassembly of valves, pumps, flanges, etc., inside the MSD pump room or below the overflow must be conducted per NSTM, NAVSEA S9086-T8-STM-010, Chapter 593, paragraph 8.3.4.

c. Personnel working in the MSD pump room or any space containing CHT piping, must evacuate the space immediately if hydrogen sulfide is detected by a "rotten egg" smell or by a portable personal hydrogen sulfide alarm. A space in which hydrogen sulfide has been detected may only be reentered by personnel wearing airline respirators with full face masks.

d. Corrective maintenance not requiring immediate attention should be deferred until the ship is port and industrial facilities are available. In a situation where holding wastes presents a health or safety hazard, the system should be secured, and an engineering casualty report filed. If retention of waste interferes with operational effectiveness, it may be diverted over the side.

e. Smoking, eating, or drinking is never permitted inside MSD pump rooms or when working on any MSD component.

7-23. <u>MSD Pump Room Safety</u>

1. In most cases, MSD pumps are located in very small compartments on lower deck levels. This provides an excellent collection basin for heavier-than-air gases, such as hydrogen sulfide.

2. To eliminate hazardous gas exposures in MSD pump rooms, it is strongly recommended that:

a. Slightly negative pressure ventilation, to include powered air supply and exhaust ventilation be installed in MSD pump rooms. The exhaust ventilation ducting should extend to within 9 inches of the deck.

b. An indicator light be installed outside the compartment to indicate the ventilation system is operating.

c. Two emergency escape breathing devices be placed in each MSD pump room.

d. A portable hydrogen sulfide detector be used during all MSD maintenance.

e. A placard be installed at access to the MSD pump room stating:

SEWAGE SPILLS PRODUCE HAZARDOUS GASES

1. *SEWAGE SPILLS CAN PRODUCE HAZARDOUS GASSES.*

2. USE EMERGENCY ESCAPE BREATHING DEVICE MOUNTED IN PUMP ROOM FOR EMERGENCY ESCAPE IN EVENT OF SEWAGE SPILL.

3. FOLLOW SAFETY PROCEDURES IN NAVAL SHIPS TECHNICAL MANUAL, "POLLUTION CONTROL," NAVSEA S9086-T8-STM-010/CHAPTER 593 DURING SYSTEM MAINTENANCE OR SPILL CLEAN UP.

4. USE SELF CONTAINED BREATHING APPARATUS ONLY FOR EMERGENCY RESCUE AND DAMAGE CONTROL (SECURING OF FLOODING).

f. This label plate be placed in the vicinity of each MSD holding tank access and sewage tank access:

TOXIC OR EXPLOSIVE GASES MAY EXIST IN THE TANK. DO NOT OPEN UNLESS AT A SUITABLE INDUSTRIAL ACTIVITY AND TANK HAS BEEN CERTIFIED GAS FREE PER REQUIREMENTS OF NAVAL SHIPS TECHNICAL MANUAL, "POLLUTION CONTROL," PUBLICATION NAVSEA S98086-T8-STM-010/CHAPTER-593.

g. A safety watch with a spare self contained breathing apparatus must be posted at the compartment access any time maintenance is conducted which requires the system to be opened in the pump room, or in any space below the MSD tank overflow.