CHAPTER 19

NONPOTABLE WATER SYSTEMS

This chapter will discuss nonpotable water systems used in various types of facilities. Systems included are recycled (gray) water and salt water.

RECYCLED AND GRAY WATER

DEFINITIONS

There is no specific, universally accepted definition of gray and recycled water. In many cases, the expressions have been used interchangeably. In general, the term *gray water* is intended to include appropriately treated water that has been recovered from typical fixtures such as lavatories, bathtubs, showers, and clothes washers. Waste potentially containing grease such as that from kitchens and dishwashers are excluded, as well as waste from food disposals in kitchens. *Recycled water* is intended to include ''clean water'' discharged from sewage treatment or other waste treatment facilities that has been additionally treated to remove bacteria, heavy metals, and organic material. *Black water* is water recovered from plumbing fixtures, such as water closets and urinals, that discharge human excrement. This handbook will limit discussions to gray water only, unless it specifically mentions otherwise.

GENERAL

Gray water systems have been in use for long periods of time in various areas of the world. In localities where the underground aquifers are in danger of depletion and where adequate supplies of water are dwindling, the reuse of water offers a considerable saving of water resources. Wastewater management is also a significant reason for gray water system use.

Onsite reclamation and recycling of relatively clean, nonpotable water is considered for the following situations:

1. In areas where code mandates that gray water be used because potable water is in short supply or its use is restricted
2. For projects where public liquid sewage disposal capacity is either limited or inadequate
3. For economic reasons when obtaining potable water or disposing of liquid waste is very costly
4. For economic reasons alone, where the time of payback will be economically feasible and will result in substantial operating cost savings

COMMON USES

Appropriately treated gray water is commonly used for the following purposes:

1. Flushing water for water closets and urinals
2. Lawn irrigation

3. Cooling tower makeup
4. Decorative pools and fountain fill water
5. Floor and general hard surface washdown
6. Laundry prerinse water

The most often used purpose is to provide water for flushing of urinals and water closets.

CODES AND STANDARDS

There are no nationally or regionally established model codes mandating or requiring the use of gray water. Conversely, the use of gray water is not prohibited. Many specific local areas have established requirements for the use of gray water in facilities and homes. Where gray water use is permitted, local health departments have established minimum treatment standards. These localities must be contacted for applicable regulations in the same manner as for plumbing and building codes. NSF International has established recycled water quality standards in certification standard No. 41.

SYSTEM DESCRIPTION

A gray water system collects the dilute wastewater discharged from lavatories, service sinks, baths, laundry tubs, showers, and other similar types of fixtures. This water is then filtered or treated to a level of quality consistent with its intended reuse. The piping network distributes it to sources not used for human consumption in a safe and distinctive manner.

A gray water system requires modifications to the standard plumbing systems throughout the total facility to accommodate duplicate drainage systems. Instead of all of the liquid discharged from all the plumbing fixtures going to the sanitary sewer, selected fixtures have their effluent routed for recovery by the gray water treatment system and the remainder to the sanitary sewer. There is also a duplicate water supply: potable water to lavatories, sinks, showers, and so on and gray water to water closets, urinals, and other fixtures permitted by the quality of gray water treatment.

SYSTEM COMPONENTS

The following components are generally used for most systems. Their arrangement and type depend on the specific treatment system selected.

1. The gray water collection piping system, which is a separate drainage system
2. The primary waste treatment system consisting of turbidity removal, storage, biological treatment, and filtering

3. Disinfection systems, consisting of ozone, ultraviolet irradiation, chlorine, or iodine
4. Treated water storage and system distribution pressure pumps, and piping

DESIGN FLOW

It is estimated that two-thirds of the wastewater discharged from a typical household in 1 day is gray water. Of this, one-half is from water closets. The discharge from the separate piping system supplying the gray water system should be sized on the applicable plumbing code. The following should be considered in the design of a system:

1. The design flow is based on the number of people in a facility.
2. Lavatory use is estimated at 0.25 gallon per toilet use.
3. Men use the urinal 75 percent of the time and water closets 25 percent of the time.
4. The average person uses a toilet 3 times per day.

TREATMENT SYSTEMS

Treatment systems vary widely. The treatment system conditions the recovered water to a degree consistent with both the intended use of the conditioned water and the design requirements of the design engineer, applicable code, or the responsible code official, whichever is the most stringent. Typical flow sheets used for various types of projects are shown in Fig. 19.1. The size of the treatment systems available vary from those installed for individual private dwellings to those serving multiple-family facilities.

The selection of a treatment system must also depend on the quality and type of the influent water. In order to decide on the most appropriate treatment, a decision must be made as to which kind of fixture discharge is to be used for reclaiming and the requirements of the authorities for treatment.

One example of water quality standards used for a multiple-family dwelling project is listed in Table 19.1. Normal process efficiency obtained from commonly used treatment methods is listed in Table 19.2.

PRECAUTIONS

Since gray water is a potential health hazard, a great deal of care must be exercised once the system is installed. One of the greatest dangers is the possibility that the gray water will be used for drinking purposes or a cross connection inadvertently will be made so that the gray water system is connected to the potable water system.

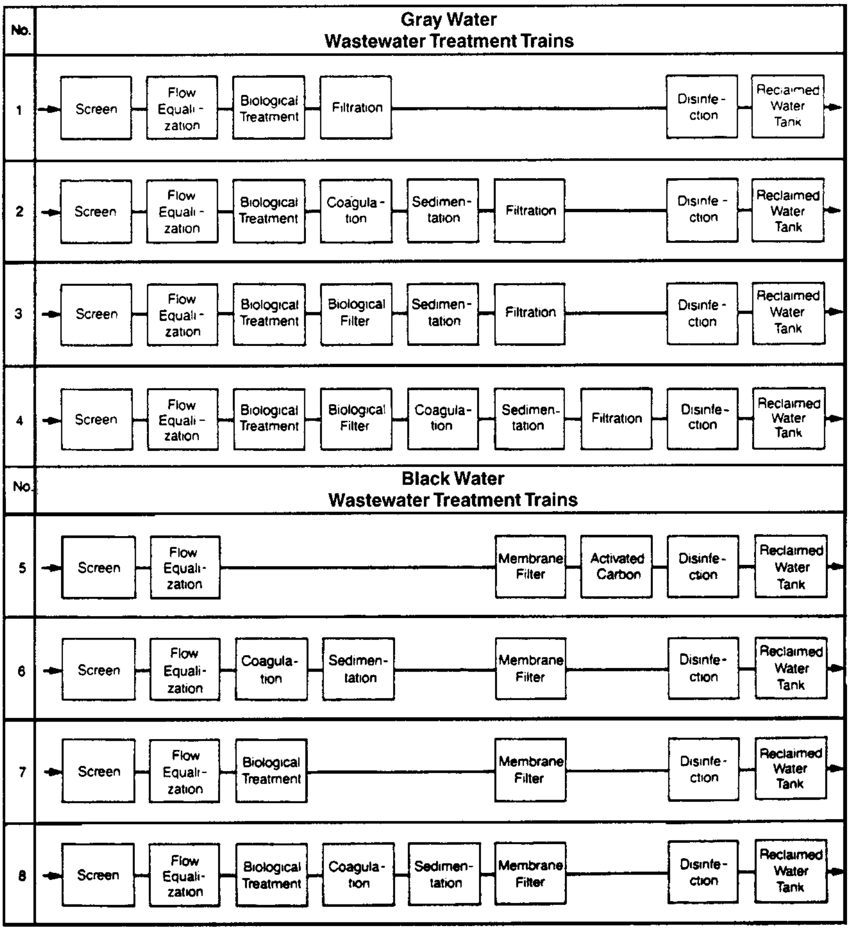

FIGURE 19.1 Typical flow sheets for on-site reuse systems.

To avoid this possibility, the water itself and the piping system must be made easily distinguishable.

Treated water could be colored by food dye that is biodegradable. Fixtures could be bought in the color of the water if the water color is found to be objectionable. The piping system itself must be clearly identified with labels. If possible, the piping material should be different so that the possibility of mistaking the two systems will be unlikely.

The most important consideration is education of individuals and the staff of any facility. Informing the staff of the dangers, as well as the proper operating instructions, will ensure that the system will be operated and maintained in a correct manner.

TABLE 19.1 Water Quality Standard for Multiple-Family Dwelling

Item	Unit	Criterion
Odor	—	
Color	Unit	<10
Turbidity	Unit	<5
TDS	mg/L	<1,000
SS	mg/L	<5
pH	Unit	5.8–8.6
COD	mg/L	<20
BOD_5	mg/L	<10
PO_4^{3-}	mg/L	<1.0
ABS	mg/L	<1.0
Coliform	count/mL	
General bacteria	count/mL	<100
Residual chlorine	mg/L	>0.2
TOC	mg/L	<15

TABLE 19.2 Normal Process Efficiency for Gray Water Treatment Methods

	Percent removal					
Process	Suspended solids	Biological oxygen demand	Chemical oxygen demand	Phosphates, PO_4	Nitrogen	Total dissolved solids
Filtration	80	40	35	0	0	0
Coagulation/filtration	90	50	40	85	0	15
Chlorination	0	20*	20*	0	0	0
Water treatment	95	95	90	15–60	50–70	80
Absorption (carbon filtration)	0	60–80	70	0	10	5

*Nominal, additional removals possible with superchlorination and extended contact time.

PUBLIC ACCEPTANCE

Although the use of gray water is a proven, safe, and cost-effective alternative for using potable water in various systems, there is a reluctance on the part of authorities to allow approval. Some other reasons are:

1. There is no generally accepted standard for the quality of recycled water. Several states in the United States, Japan, and the Caribbean have adopted codes and guidelines, but, for most of the world, there is no universal standard. This has

resulted in disapproval of the systems or long delays of a project during the approval process where the quality of the water is in question.

2. Even when regulatory and plumbing codes do not have any specific restriction against using gray water or have ambiguous language that could be interpreted for its use, some officials still impose special standards due to their lack of experience.

TYPICAL INSTALLATIONS AND DETAILS

1. A typical black water treatment system is illustrated in Fig. 19.2.
2. A typical gray water treatment system is illustrated in Fig. 19.3.
3. A simplified gray water dual-piping distribution system is illustrated in Fig. 19.4.
4. A simplified high-rise water and waste piping distribution system is illustrated in Fig. 19.5.
5. A typical laundry wastewater recovery system is illustrated in Fig. 19.6.

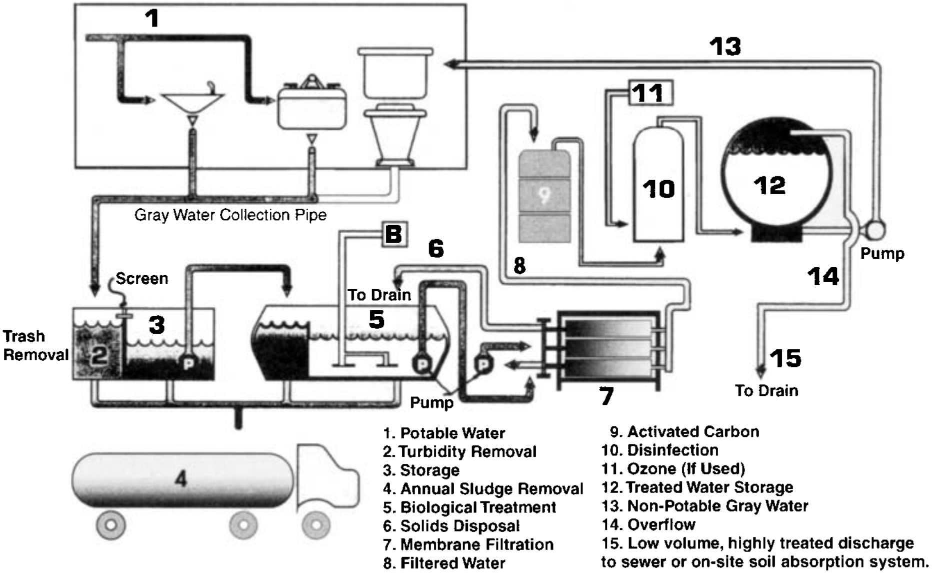

FIGURE 19.2 Typical black water treatment system.

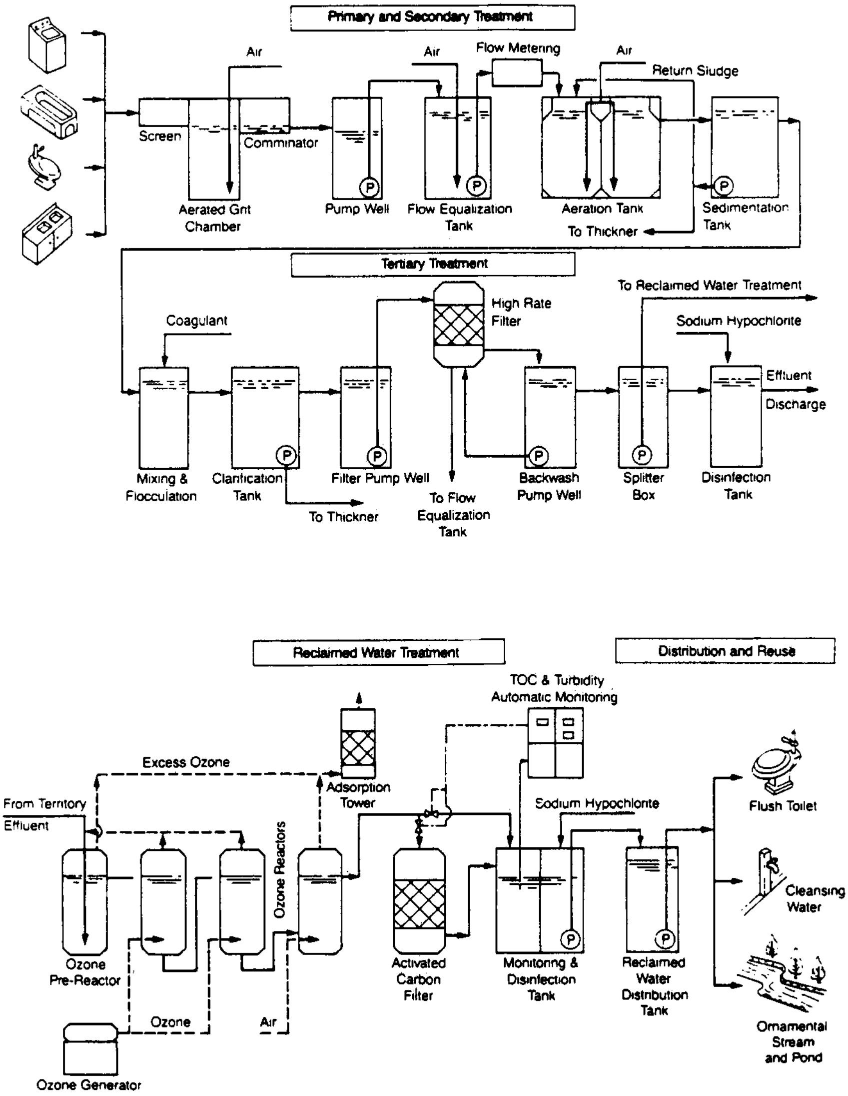

FIGURE 19.3 Typical gray water treatment system.

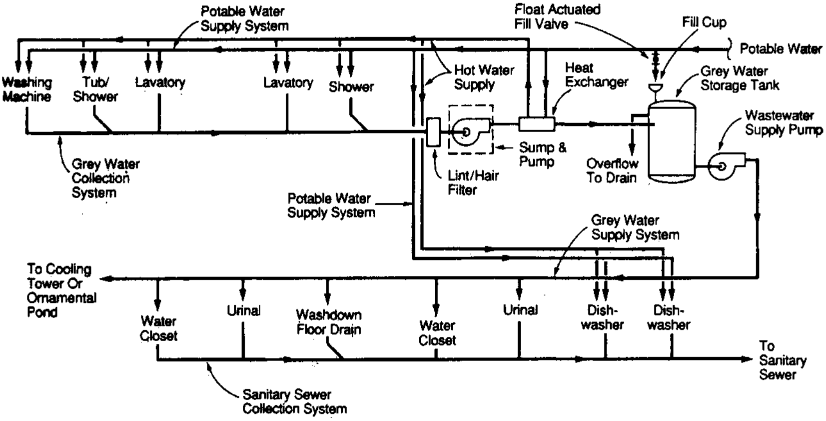

FIGURE 19.4 Typical gray water dual piping distribution system.

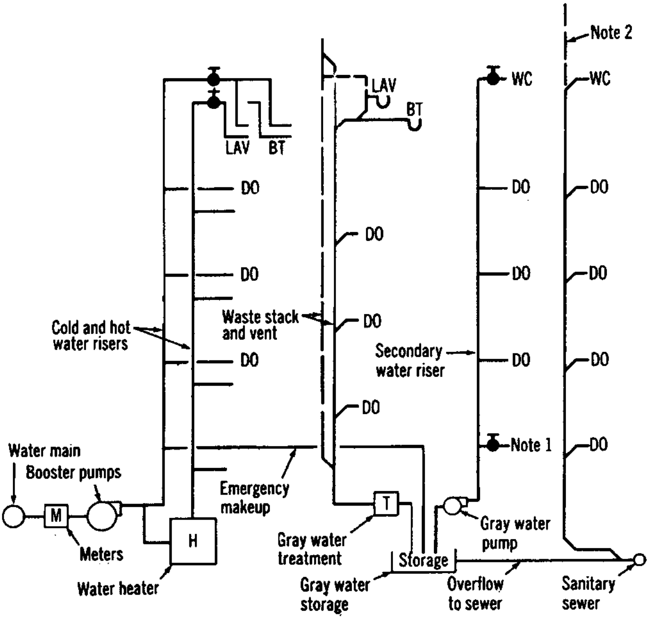

FIGURE 19.5 Typical high-rise dual distribution system. Notes: (1) Gray water can also be utilized for other uses such as irrigation, and cooling tower makeup, providing that treatment is adequate. (2) Common vent for both drainage stacks.

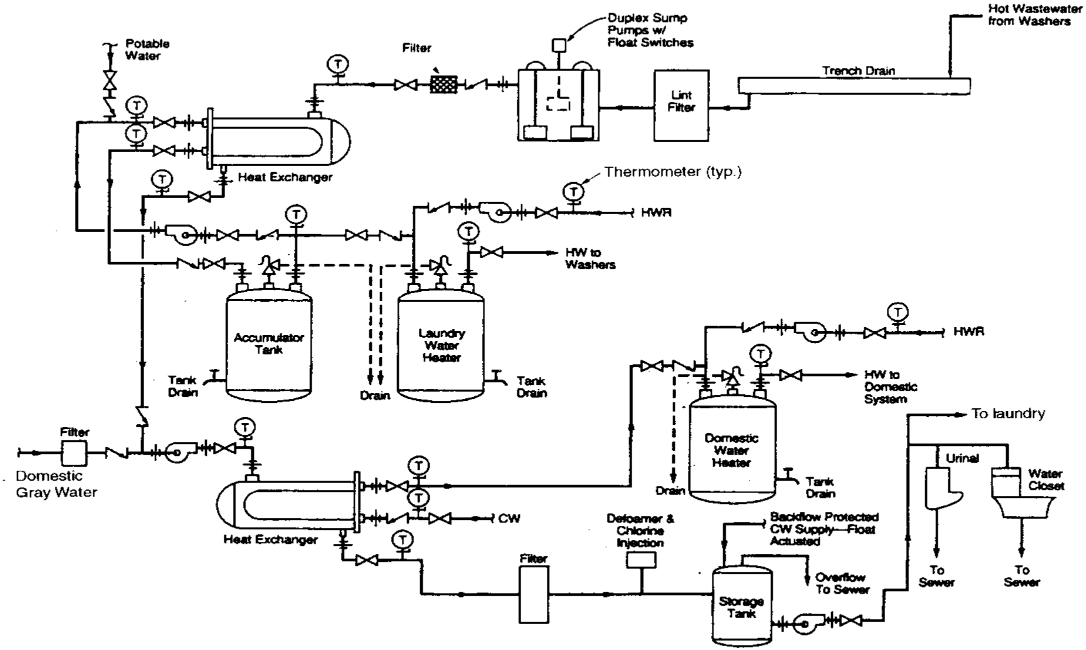

FIGURE 19.6 Laundry waste recovery system.

SEAWATER

GENERAL

Seawater is used in many situations including desalinization systems and saltwater aquariums; it is also used as a heat exchange medium and as flushing water for water closets. The major differences between seawater and other types of nonpotable water are that the water is reasonably clean, there are living organisms present in the water source, and the seawater accelerates corrosion to metallic pipes and valves.

Living organisms include those that swim in the water and those that are permanently attached, some with hard and soft shells, no shells, and some that move. They attach themselves to the walls of the pipe or intake structure and can multiply at an alarming rate. When dead, their remains adhere to the surface they attached themselves to.

CODES AND STANDARDS

There are no nationally or regionally established model codes concerning the use of salt water. If salt water is to be used, say, for flushing toilets, then the gray water regulations established in the plumbing and health codes for the locality where the project is located must be followed.

METHODS OF PREVENTING ATTACHMENT OF ORGANISMS

The greatest problem in saltwater systems is the attachment of organisms onto the piping in the distribution system. There are several methods used to prevent their attachment to the pipe, control their presence, and eliminate them. The method depends on the final use of the water.

Copper-bearing pipe materials discourage attachment. The drawback is that copper is known to damage the ecology and should not be used except in a closed system where the seawater will not be released back to the ocean.

Toxic chemicals will kill all living things when introduced into the water. In aquariums, killing organisms with toxic cleaning agents is not possible since, in the event of an accident, the toxins could kill the exhibited fish.

Having redundant piping systems and allowing one of them to be isolated for a period of time will permit two methods of control. One process would be to valve off the pipe and starve them with a lack of food and oxygen. This method takes several weeks to accomplish and is very costly. Another method would be to flood the piping with warm freshwater. This takes a shorter period of time based on the type of organisms present.

In the case of once-through seawater used for cooling purposes, a high water velocity (10 fps) is enough to keep any organism from attaching itself to the pipe wall. This velocity has to be balanced against erosion of the pipeline.

PIPELINE CLEANING

Once shells are attached, they remain firmly attached after death and have to be removed. Inside a pipe, this can be done only by a mechanical scraping operation. One method popular for smaller lines uses a plumber's snake in the same way that a sanitary sewer line is cleaned. Another method is called *pigging.* A pig is an object that fits inside a pipe, and its circumference is large enough to scrape the inside as it passes. The pig is powered by flowing water in the pipe. There are many configurations of pigs possible, and some are made with stiff wire brushes or cone-shaped scrapers for cleaning the pipe walls.

Because of pigging, unique design considerations are required in the piping system. There should be no control valves, no fittings greater than 45°, and no protrusions such as thermometers or flow meters inserted into the pipe line to be pigged. An adequate number of cleanouts throughout the system is very important. In lines that cannot be pigged or cleaned, pipe sections capable of being removed from the system should be provided in order to gain easy access. Lines smaller than 2 in cannot be pigged, but generally accepted practice is not to pig a line smaller than 4 in. The smaller lines are cleaned with rotating plumbing snakes. A pig launching piping arrangement is detailed in Fig. 19.7, and a recovery arrangement is detailed in Fig. 19.8. Pigging is very often used to clean piping for other systems. Clearing intake structures such as screens usually requires a diver who must clean them by hand.

FILTERS

Filters are used to remove virtually all living things from the source of water and to improve clarity of the water when this is a consideration. Sand filters are the most commonly used, with FRP or rubber-lined tanks. Readers inside the tanks are PVC, and the filter medium support is FRP. Backwash is piped back to the ocean.

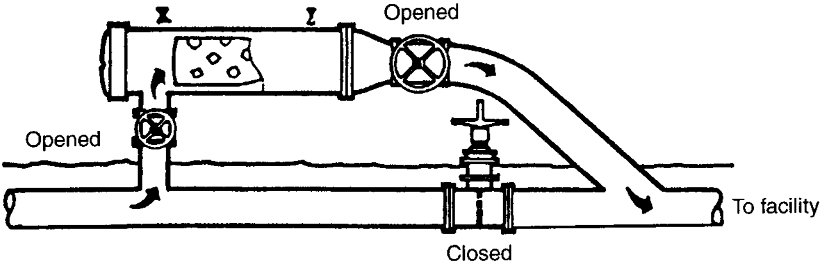

FIGURE 19.7 Typical pig launching detail.

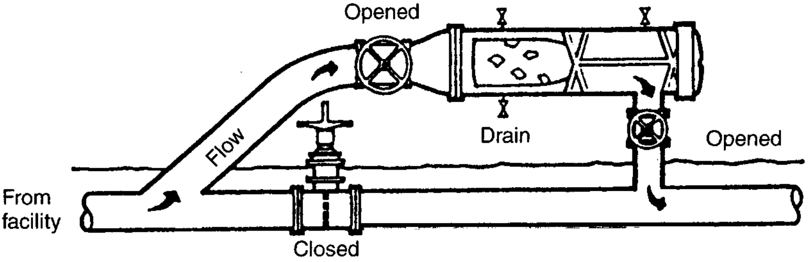

FIGURE 19.8 Typical pig recovery piping detail. (*Courtesy Girard Industries Incorporated.*)

SEAWATER INTAKE

Seawater taken directly from the ocean is susceptible to the intake of debris, sand, fish, and other living things. The intake structure must be designed to act as a primary screen to eliminate them. A typical intake structure is schematically illustrated in Fig. 19.9.

An intake structure provides a reservoir for the facility's main seawater supply pump. The natural level of the ocean at low tide must be high enough to provide a sufficient amount of water and allow for an additional lowering of the water level during pumping.

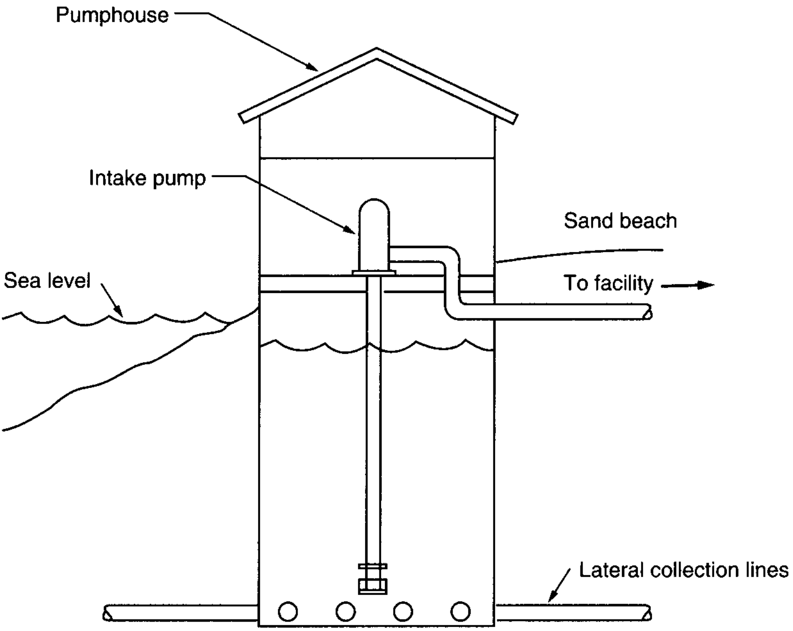

FIGURE 19.9 Typical intake structure.

Where the supply must provide the full range of living things, the inlet piping may have to extend out along the ocean floor several hundred feet to permit obtaining the desired water quality. The actual inlet should be covered with a bar screen or a cylindrical stainless steel mesh screen. A 1½ × ¾-in size mesh has worked well and is light enough to be easily handled by a diver using a flotation device. Experience has shown that bar screens foul faster than mesh screens, and in addition, are much heavier. A typical schematic of an intake pipe installation is shown in Fig. 19.10.

If relatively clear water free from living organisms is acceptable, an intake structure built in the sand close to shore should be considered. The water is obtained from perforated pipes run in the sand, using the sand itself as a filter medium before it reaches the inlet structure. This type of installation requires a large and deep sand beach. A typical intake structure is illustrated in Fig. 19.9.

Another solution to controlling the fouling of salt water intakes and piping is the introduction of chemicals at the intake structure. These chemicals must be acceptable to regulatory agencies and could include sodium hypochlorate, hydrogen peroxide plus iron, potassium permanganate, chlorine dioxide, chloramine, and ammonia. This system could include space for chemical storage, chemical metering pumps, and transfer pumps.

PIPING MATERIALS

The material of choice for most piping installations is plastic. PVC, CPVC, and PVDF are used based on temperature and the chemical nature of any cleaning solution. PVDF is useful at elevated temperatures. Another consideration is the abrasion to the pipe that would be caused by pigging. FRP pipe is used when physical strength is a factor, such as that used for intake piping. Special epoxies can be used in the manufacture of the FRP pipe to make it more abrasion resistant. When environmental considerations are not a factor and physical strength is important such as when salt water is used in heat exchangers, 90-10 copper nickel

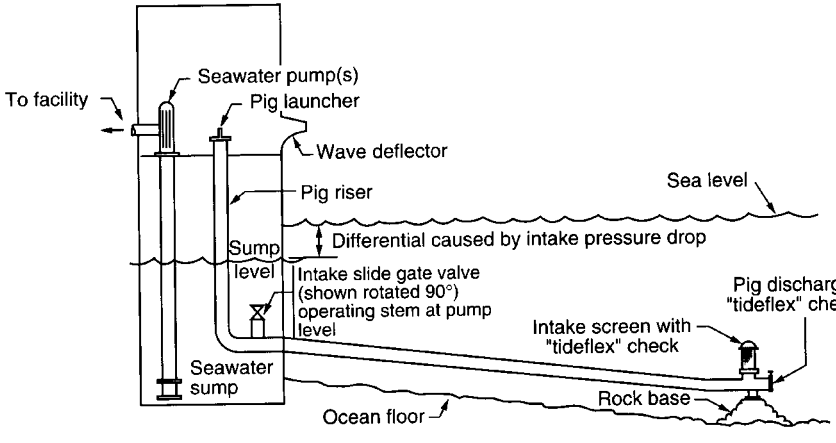

FIGURE 19.10 Intake pipe schematic detail.

alloy pipe is recommended. Experience has shown that stainless steel is not effective as a pipe material. If its use is unavoidable, design that component to be easily replaced. Titanium has often been used for critical applications but does not find general use because of cost.

Valves should be made of plastic, FRP, monel, copper-nickel, or marine bronze with a proven resistance to seawater. Coated surfaces have not proven effective, particularly epoxy-coated steel and cast iron.

Other materials such as rods and bolts should be made of FRP, as well as structural shapes and gratings. Cementing FRP together is effective, providing that the surfaces to be mated are clean and rough. FRP reinforcing rods are available for concrete exposed to seawater.

EQUIPMENT SELECTION AND MECHANICAL ROOM DESIGN CONSIDERATIONS

Pigging requires extra space to launch and recover the pigs. Space and a method to collect debris must be allowed for. Adequate space for the removal of filters is important. Pumps made of plastic materials are available, as well as those constructed with rubber lining and of FRP material. Large pumps can be obtained with removable end plates if desired. Because of the uncertainty of system conditions, duplex equipment is required for any critical operation.

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