CHAPTER 7

WASTEWATER COLLECTION

7-1. General.

The basic criteria for design of sewarage systems for military facilities are in TM 5-814-1/AFM 88-11, Vol.1, and TM 5-814-2/AFM 88-11, Vol.2. The unique aspects of design and construction of these systems in the cold regions are in this section. In addition some further detail is included on the use of pressure and vacuum sewers since the flat terrain and permafrost make it difficult to design a conventional gravity sewer system in the Arctic. Combined utility systems called utilidors are covered in chapter 8. Table 7-1 compares the characteristics of gravity, vacuum and pressure systems for use in cold regions. Vehicle hauling of water and wastewater is still used at some remote sites, but for the general case, military facilities will be serviced by piped collection systems. Normally, a conventional gravity sewer system will have the lowest life-cycle cost and must be used whenever practicable. Gravity systems have an additional advantage over pressure systems in that they seldom flow full. As a result gravity pipes are less likely to break if freezing occurs.

7-2. Design considerations.

As described in chapter 2, the location of the pipe, above or below ground, is critical to satisfactory performance. An above-ground location with the piping installed on piles may be necessary because of soil conditions. However, the grades necessary for gravity flow are difficult to maintain with above-ground sewers. Above-ground sewers also hinder transportation, block surface drainage and snow removal, have high heat losses, and are more susceptible to vandalism. The operation and maintenance costs for above-ground systems are about three times higher than those for similar systems buried undergound. Above-ground construction costs for a single pipe depend on the foundations required. If the pipe can be laid directly on the surface, construction costs will be 20 to 40 percent of that required for the same pipe installed on piling.

a. Sewage temperatures. Domestic wastewater from barracks, mess halls and family housing on military installations in the cold regions will range from 50 to 60 degrees F at the source. Wastewater from facilities not having hot water heaters can be as

Table 7-1. Characteristics of wastewater collection systems.

Type	Soil Condition	Desirable Topography	Economics	Other
Gravity	Non-frost-susceptible or *Slightly* frost susceptible with gravel backfilling material.	Gently sloping to prevent deep cuts or lift stations.	Initial construction costs high but operational costs low unless must install above ground or use lift stations.	Low Maintenance. Must have adequate grade. Flushing of low use lines may be necessary. Large diameter pipes necessary.
Vacuum	Most useful for frost susceptible or bedrock conditions, but can be used with any soil conditions.	Level or gently sloping.	Initial construction cost moderately high.	"Traps" every 300 ft. Low water use. Must have central holding tank for each 30 to 50 services with additional pumps to pump waste to treatment facilities.
			Operational costs moderate.	Can separate gray and black water. Uses small pipes. No exfiltration.
Pressure	Most useful for frost susceptible or bedrock conditions, but can be used with any soil conditions.	Level, gently sloping or hilly.	Initial construction costs moderate. Operational costs moderately high.	Low water use if water use fixtures are installed. Number of services not limited. No infiltration. Uses small diameter pipes.

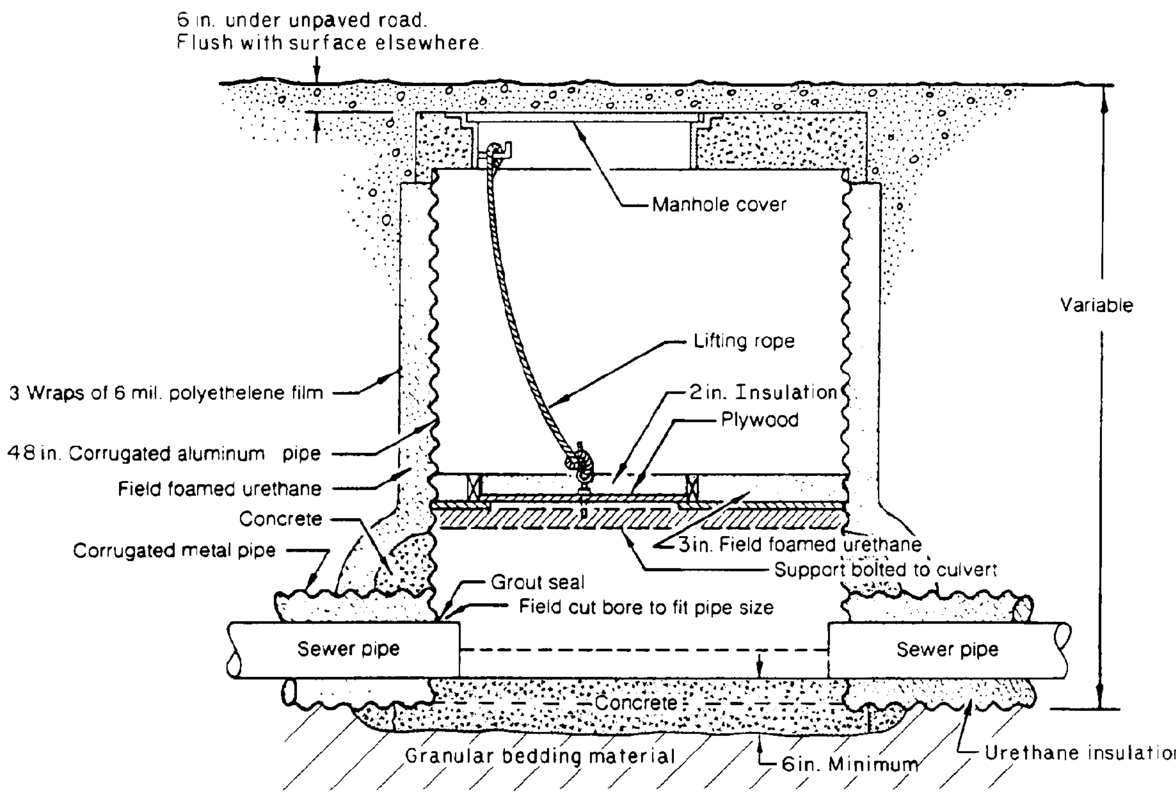
low as 35 degrees F. The temperature of wastewater in utilidors (chapter 8) can be increased if steam or hot water lines are also included in the utility package. The thermal design of the sewer piping (chapter 12) must include these wastewater temperatures for cost-effectiveness. Storm water will not be admitted to sewers in cold regions. It lowers the temperature of the wastewater and increases the cost of pumping, treatment, and disposal.

b. Pipe materials. The materials selected for sewerage systems will be in accordance with the criteria given in TM 5-814-1/AFM 88-11, Vol.1. Paragraph 6-5 in section 6 of this manual discusses the cold climate aspects of these materials.

7-3. Appurtenances.

These include manholes, cleanouts, building or service connections, and flushing siphons.

a. Manholes. Figure 7-1 illustrates typical details for a buried sewer manhole structure in the cold regions. A plastic film wrapped around the outside of the manhole will be required to prevent bonding of the soil to the structure and thereby prevent damage from frost heaving. Typically, such manholes have been insulated with a minimum of 3 inches of polystyrene or urethane around the outside, with a plastic film or other external coating to prevent moisture damage to the insulation. An insulated cover will be provided over the wastewater chamber to further reduce heat loss. A firm foundation is essential, and may require either piling or excavation, and then sand and gravel backfill. If a poured-in-place concrete invert is used in the manhole as shown in figure 7-1 and permafrost is at a relatively shallow depth, the concrete will be placed on insulation board to reduce the downward heat losses. Spacing of manholes will be in accordance with TM 5-814-1/AFM 88-11, Vol.1. Solid manhole covers will be required to prevent entry of surface water.



U.S. Army Corps of Engineers

Figure 7-1. Typical sewer system manhole.

b. Cleanouts. Cleanouts are typically used in building connections and in some cases are installed in place of manholes as described in TM 5-814-1/AFM 88-11, Vol.1. They must be used with caution in cold regions since they are difficult to protect and are susceptible to frost heaving. Figure 7-2 illustrates details of a cleanout that has been successfully used in Canada.

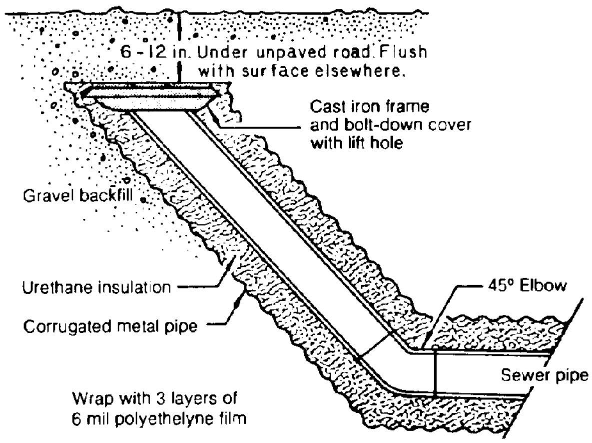


Figure 7-2. Typical cleanout.

c. Siphons. Sewers subject to low flows and velocities must be avoided if possible in the system design since a trickle flow may result in gradual freezing and ice build-up in the pipe. If such sewers are necessary, then a pump station or a flushing siphon must be included. These must be designed to discharge a slug of relatively warm water into the system. If there is insufficient wastewater available to operate the siphon frequently enough to avoid freezing, it may be necessary to add water as shown in figure 7-3, with proper precautions taken to prohibit cross connections.

d. Building connections. Figures 7-4 and 7-5, for buildings on pile or post foundations, show typical connections for a gravity sewerage system in cold regions The wall penetration shown in figure 7-4 is more flexible than the floor penetration in figure 7-5, and will permit more differential settlement without damage to the sewer line.

7-4. Pump stations.

The basic hydraulic design of pumping stations will be in accordance with TM 5-814-2/AFM 88-11, Vol. 2. Special requirements and concerns for use in cold regions are discussed below.

a. Insulation. The outside of the station structure will be insulated with at least 3 inches of urethane or polystyrene, with an outer covering to protect the

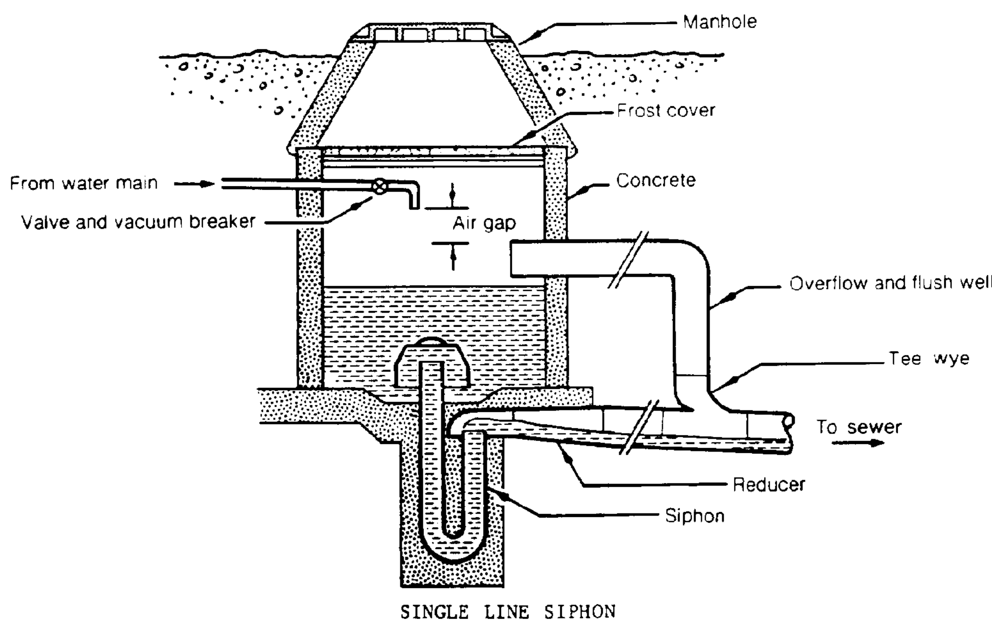
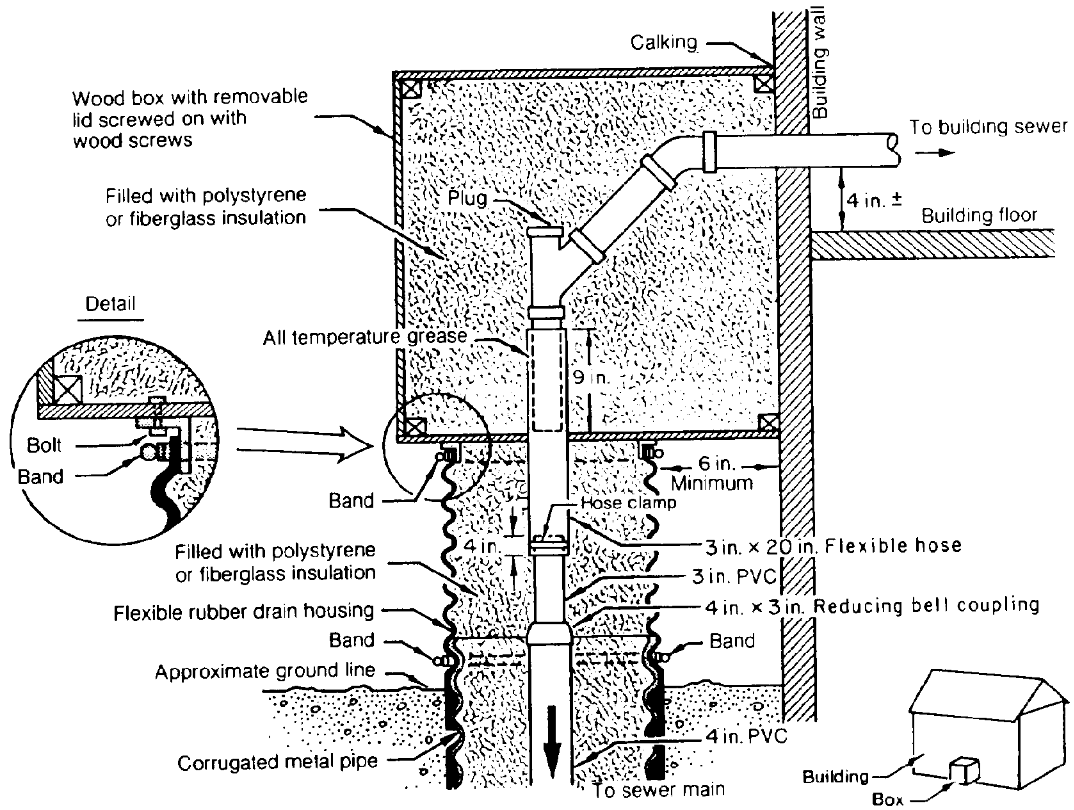
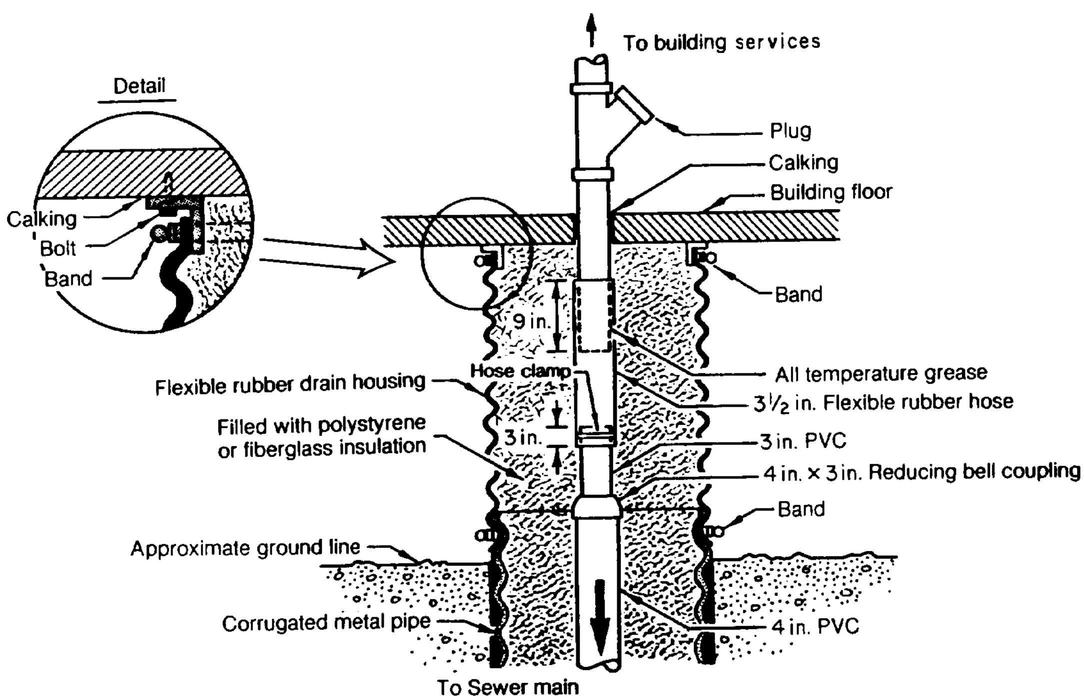


Figure 7-3. Typical siphon.



U.S. Army Corps of Engineers

Figure 7-4. Typical service connection (wall).



U.S. Army Corps of Engineers

Figure 7-5. Typical service connection (floor).

insulation from moisture. Insulation will also be placed beneath the station when permafrost is present at a shallow depth to prevent settling due to ground thaw. A plastic film or some other bond breaker will be required to reduce frost jacking in the active layer (see further discussion, para 11-3). If thawing and settling under the station are anticipated, pile foundations extending well into the permafrost will be required. All stations must be attached to concrete base slabs to provide sufficient weight to overcome the buoyancy of the station. Pressure couplings or flexible connections are required for the inlet and outlet pipes to prevent station differential movement from breaking the lines.

b. Condensation. A prefabricated, below-grade pumping station must not be installed without immediately placing the heater and dehumidifier into operation. Condensation caused by the surrounding cold earth could corrode the controls and electrical equipment before the system is actually put into service.

c. Alarms. Alarms must be provided in accordance with the requirements of TM 5-814-2/AFM 88-11, Vol. 2. All critical components, such as pumps and compressors, must be duplicated in each station. In addition, alarms must be set to warn of freezing temperatures in the station and to warn of sump pump malfunctions. Alarms must be annunciated as described in TM 5-814-2/AFM 88-11, Vol.2.

d. Standby power. Due to the dangers of freezing associated with extremely low temperatures, standby power facilities must be provided for each major pump station.

e. Maintenance. During freezing conditions, each pump station must be checked daily by the operator. All entrance manholes must extend sufficiently above the ground surface to be above any flooding or snow drifts. All pump stations will be supplied with devices for measuring flow rates. Corrosion protection must be provided in accordance with TM 5-814-2/AFM 88-11, Vol.2. Sacrificial anode type systems do not work well when the ground surrounding the anode or pump station is frozen.

f. Force mains. Force mains will be designed to have scour velocities during pumping (2.5 to 3.5 feet per second) and to drain between pumping cycles. This can be accomplished by an electrically operated ball valve in the line to allow drainage back into the wet well between pump cycles. If this is not possible the line must be placed in a heated utilidor or heat traced. Another option would be to time the pumping cycle so that wastes stay in the line for a calculated period, and to size the wet well at the pump station to hold at least the volume of the force main.

7.5 Pressure sewerage.

The main advantage of pressure sewers is that specific grades need not be maintained throughout the system. Typically grinder pump units are used so that smaller diameter pipes can be installed without the risk of clogging. Grinder pumps may be installed in each building or in a holding tank serving several buildings. An alternative to grinder pumps is to install a two-compartment septic tank with a conventional submersible pump in the second compartment. The hydraulic design of these pressure systems is not unique in the cold regions and criteria found in TM 5-814-2/AFM 88-11, Vol. 2, will be used. The pressure piping must be designed to drain by gravity to a low point or sump in case the system has to be shut down in the winter. The grinder pump units, holding tanks and septic tanks must have a firm foundation and must be protected from frost heaving as discussed previously for manholes (para. 7-3*a*)**.** Water conservation measures in each of the buildings served is required to reduce the costs of equipment and energy for pumping.

7-6. Vacuum sewerage.

Vacuum sewers do not depend on a specific grade for successful operation. They operate at a vacuum of 8-10 psi, and so are limited to an elevation difference of 15 to 20 feet within the system. The hydraulic design is not unique to the cold regions. The concept depends on providing traps in the system to maintain a vacuum. Since these traps are full of water for extended periods, they must be insulated and/or heated for extreme low temperature conditions. The traps should also be drainable under emergency situations. A 50 house vacuum system in Noorvik, Alaska, was installed in 1977 and has operated successfully, since that time.