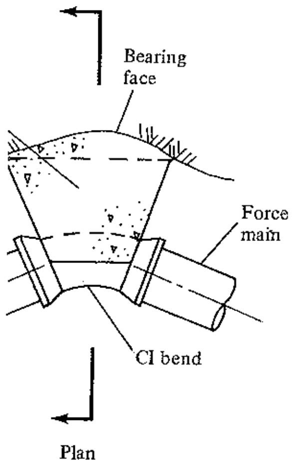

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As a further precaution against hydrogen sulfide problems, especially in hot climates, it may be desirable to seal the outlet of the force main pipe. The sewer can be sealed by placing the crown of the force main pipe outlet at the same elevation as the invert of the gravity sewer, with the manhole invert sloping upward from the force main outlet to the sewer. The seal may also be provided with a trap formed with pipe fittings.

Force Main Appurtenances

Common force main appurtenances include blowoffs, access manholes, and air and vacuum valves.

Blowoffs. A blowoff is a controlled outlet on a pipeline, so arranged that it can be used to drain or flush the pipeline. Blowoffs normally are not required on force mains. However, where the force main contains a long depressed section between high points, a blowoff may be desirable in case the force main must be drained and pumped out.

A suitable blowoff might consist of a valved connection in a manhole at the low point, discharging to a manhole or vault that would serve as a wet well for a portable pump. The size of the blowoff should not be less than 150 mm (6 in). It should, if possible, be large enough to provide flushing velocities in the force main.

Air valves. Force mains are usually constructed at approximately uniform depths below the ground surface. This practice often results in high and low points along the course of the pipeline. In such cases, it may be necessary to provide valves for the release of trapped air when putting the line in service (filling) and during regular operation, or for admitting air should it be necessary to drain the force main. The release or admittance of air for filling or draining can be accomplished by use of a manually operated air valve. Specially designed automatic air release valves have been used for bleeding air from high points while the force main is under pressure.

If possible, force mains should be designed without high points, and with the top of the force main below the hydraulic grade line at the minimum pumping rate so that air-relief valves will not be needed. If the elimination of high points is not feasible, a manual air-release valve should be installed at each significant high point where air could become trapped. A high point may be considered significant if it is 0.6 m (2 ft) or more above the minimum hydraulic grade line or, when pumping is intermittent, above the static head line. Air-release valves should not be less than 20 mm (3/4 in) nor more than 50 mm (2 in) in size. Larger sizes should be used with larger-diameter force mains. Preferably, these valves should be located in vaults, but a valve of 40-mm (1 1/2-in) diameter or larger may be buried in the ground and operated with a wrench through a box. An air-release valve may discharge to a sewer manhole, a vented dry well, or other suitable place. Consideration should be given to providing a means of rodding out or back flushing the valve. A typical air valve installation for a force main is shown in Fig. 9-12.

Automatic air-release valves should not be installed if their use can be avoided. From past experience it has been found that automatic air-release valves require frequent maintenance in order for them to function as intended. Inadequate maintenance causes these valves to clog and malfunction, often soon after they are installed. In most cases, manual air valves could be used instead of automatic air valves. For example, if after the force main has been put into service, the need develops for frequent use of a manually operated valve to relieve entrapped air or gas, the valve may be left at a part-open setting for continuous bleeding of air or sewage. As a last resort, an automatic air-release valve may be installed.

Automatic air-release valves, if used, must be specially designed to keep the valve operating mechanism free from contact with sewage to inhibit clogging and resulting malfunction. They must be located in a manhole or vault and protected against freezing. Automatic air valves should be installed on top of the force main with a shutoff valve close to the force main. A 25-m (1-in)

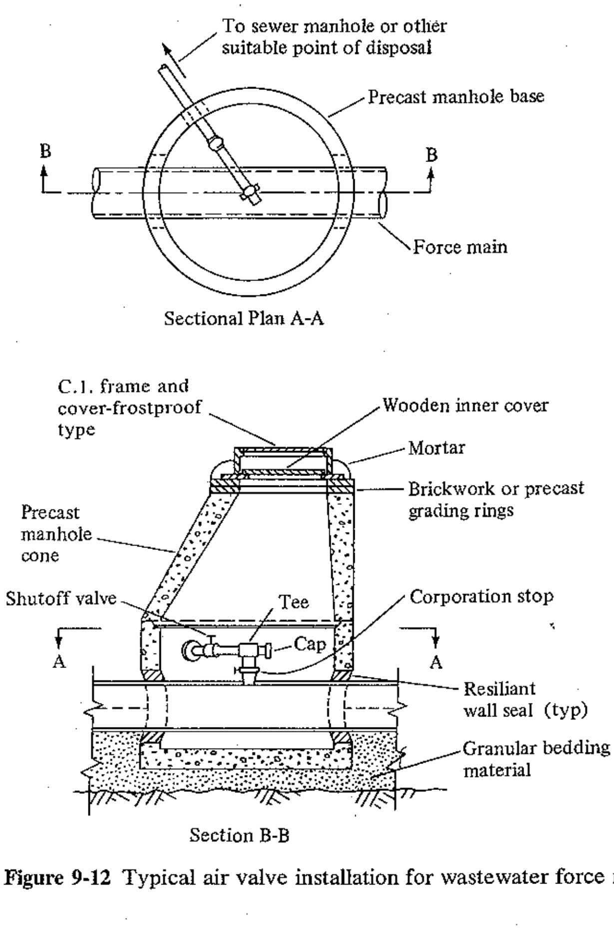

Figure 9-12 Typical air valve installation for wastewater force main.

blowoff valve should b
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9-5 WATERHAMME

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or power failure. The
cussed in this section.

Theory of Waterham

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A cycle of pressur
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blowoff valve should be installed either above the shutoff valve or on the air valve body. A back-flushing connection should be provided by the valve manufacturer.

Automatic air and vacuum valves have been used to allow the quick automatic admission of air that might be needed to prevent collapse of a thin-walled pipeline during the fast drainage that would take place through a broken force main, or during water-column separation following a power failure. They also have been used for venting air during the filling of the force main. However, these valves are subject to maintenance problems similar to those of air-release valves. Furthermore, their malfunction could create additional waterhammer problems.

In general, automatic air and vacuum valves should not be used on sewage force mains. Instead, the problem of possible collapse of force main pipes because of internal pressures less than atmospheric should be solved by the use of pipe having walls sufficiently strong to withstand the induced added crushing load.

9-5 WATERHAMMER IN WASTEWATER FORCE MAINS

The rapid changes that can occur in the velocity of flow in force mains and pressure pipe can be caused by pump startup, pump shutdown, or power failure and can result in a considerable change in pressure. The change in pressure can be either positive (above normal) or negative (below normal) and is sometimes accompanied by a hammering-type noise. This transient pressure and flow condition in force mains and pressure pipes is known as *waterhammer*. The most severe waterhammer conditions generally result during pump shutdown or power failure. The theory, analysis, and control of waterhammer are discussed in this section.

Theory of Waterhammer

In the case of rapid pump shutdown or power failure, the flow and velocity in the force main are initially steady. However, when the power supply to the pump motor is cut off, the pump rapidly decelerates from full speed to zero speed, causing a rapid decrease in the pump discharge into the force main. This decrease creates a negative-pressure wave (below normal pressure) that rapidly travels from the pumping station end of the force main to its discharge end. This negative-pressure wave decelerates the flow in the force main in accordance with Newton's second law of motion. When this negative-pressure wave reaches the discharge end of the force main, it is reflected back toward the pumping station as a positive-pressure wave, which further decelerates the flow during its passage.

A cycle of pressure wave travel is completed when the positive-pressure wave reaches the pumping station, where it is again reflected and a second insley

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WASTEWATER ENGINEERING:
COLLECTION AND PUMPING OF WASTEWATER

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