CHAPTER 4

DISTRIBUTION SYSTEMS PRESSURES

4-1. General. Water distribution systems should be designed to maintain operating pressures within the system between 40 and 75 pounds per square inch at ground elevation. Minimum pressures of 30 pounds per square inch under peak domestic flow conditions can be tolerated in small areas as long as the distribution system is also capable of meeting fire flow requirements to these areas. Minimum ground-level residual pressures at fire hydrants will be at least 10 pounds per square inch while supplying fire flows. Maximum pressures of 100 pounds per square inch can be allowed in small, low-lying areas not subject to high flow rates and surge pressures. Areas of excessively high or low pressures require that the system be divided into multiple pressure levels.

4.2 Multiple levels. Where multiple-level systems are required, it is desirable to establish the lines of separation so that the pressures in each system will approach the optimum range of 40 to 75 pounds per square inch. Three or more levels will not be used unless distribution pressures in a large area of the two-level system fall below 30 pounds per square inch, or approach or exceed 100 pounds per square inch. In all circumstances, fire flows must be adequate.

4-3. Pressure-reducing valves. Pressure-reducing valves wil be required in areas of the distribution system that have pressures in excess of 100 pounds per square inch. The pressure-reducing valves may be installed on the mains serving these areas or on the individual building service lines in high-pressure areas. If pressure-reducing valves are to be installed on individual service lines, the preferred location is adjacent to, and upstream from, the water meter for each building or immediately inside the building being served. In some cases, it may be necessary to install pressure-reducing valves only on lines to certain plumbing or heating units which are adversely affected by excessive pressures.

4.4 Pressure-relief valves. Pressure-relief valves should be installed in all systems which might be subjected to greater than allowable pressures. In systems with 100-pounds per square inch pumps, the pressure-relief valves should be set to discharge at 120 pounds per square inch; pressures greater than 120 pounds per square inch may be experienced for brief periods during testing or operation of these pumps. All pumps driven by variable speed motors or engines should be provided with relief valves; and if the shutoff pressure of any pump exceeds 120 pounds per square inch, the pressure-relief valves should be installed and set at approximately 120 pounds per square inch.

4.5 Waterhammer.

a. Definition. Waterhammer is sometimes called surge or transient pressure. The phenomena is caused by rapid changes in flow in closed conduits which cause pressure waves to travel through the liquid, both upstream and downstream from the point of origin.

b. Causes. The most common causes of waterhammer include rapid valve closure, starting and stopping of pumps and conduit failure. Types of valves include main lines, fire hydrant or reservoir fill. Other causes include a sudden stop in usage by a large customer or the sudden joining of a column of water that had been separated by a vacuum.

c. Pressure analysis. Consideration of waterhammer and transient pressure surges is based on the elastic wave theories of Joukowski and Allievi. The basic concepts are:

— the magnitude of the pressure rise is proportional to the changes in fluid velocity and pressure wave.

— the pressure rise is independent of the length and profile of the pipe.

— the velocity at the pressure wave is the same as the velocity of sound through water.

The problem becomes complex in an actual pipeline because the pressure wave is reflected at a line terminus and then travels back to the point of origin, where it may again be reflected. This continues until the wave is dampened by friction. All waterhammer problems ultimately require the determination of line pressure at one or more locations along a pipeline, at one or more points in time. The waterhammer pressure is the result of the combined effect of all direct and reflected pressure waves.

d. Prevention and control. Waterhammer due to valve closure can be minimized by the use of slow closing valves. Surges caused by the starting or stopping of centrifugal pumps can usually be prevented by use of check valves on the pump's discharge line. Other methods of control include pressure relief valves, anticipating pressure relief valves, vacuum relief valves, surge tanks and air chambers.

4-6. Cavitation. Cavitation is a complex phenomenon that may take place in pumps. In a centrifugal pump, as liquid flows through the suction line and enters the eye of the impeller, the velocity increases and pressure decreases. If the pressure falls below the vapor pressure corresponding to the temperature of the liquid, pockets of vapor will form. When the vapor pockets in the flowing liquid reach a region of higher pressure, the pockets collapse with a hammer effect causing noise and vibration. Tests have shown that extremely high instantaneous pressures may be developed in this manner, resulting in pitting various parts of the pump casing and impeller. Conditions may be mild or severe and mild cavitation may occur without much noise. Severe cavitation can result in reduced efficiency and ultimate failure of the pump if steps are not taken to eliminate the cause.