CHAPTER VI

WATER STORAGE TANKS

A. PRIMARY DESIGN CONSIDERATIONS

Water storage structures shall be stable, durable, and protective of the quality of the stored water. Construction of uncovered finished water storage reservoirs is prohibited. With the exception of vents and overflows, all piping is to be valved.

1. TYPE OF STORAGE – The choice of underground, ground level, or elevated storage depends on volume requirements, topography, hydraulic grade lines, potential for freezing, aviation hazards, security issues of water transmission and distribution lines, and availability and reliability of backup energy sources.

2. LOCATION

   a. The bottom of a ground level reservoir or standpipe should be placed at the normal ground surface such that it is at least 1 ft. (0.3 m) above finished grade and at least 1 ft. (0.3 m) above the 100-year flood level. The finished grade of the ground surface shall slope away from the reservoir or standpipe for a distance of at least 10 ft. (3.0 m) in all directions.

   b. When the bottom of a ground level reservoir or a standpipe must be below normal ground surface, it shall be placed above the groundwater table. At least 50 percent of the water depth should be above grade. Sewers, drains, fuel storage facilities (tanks and lines), standing water, and similar sources of contamination must be kept at least 50 ft. (15 m) from the reservoir. Water main pipe, pressure tested in place to 50 psi (345 kPa) without leakage, may be used for gravity sewers at lesser separations, but no closer than 10 ft. (3.0 m). Provisions for appropriate spill containment must be included in any fuel storage facility design.

   c. The top of an underground reservoir may be located below the lowest frost line to minimize freeze-thaw effects on the structure. In any case (whether the top is above or below the frost line) the top of an underground reservoir shall be both sloped to facilitate drainage and covered with an impervious membrane to protect it from contamination. Additional measures to protect the reservoir from contamination shall be employed where necessary and as approved.

d. Water quality and distribution system demand centers should be taken into consideration when selecting locations for finished water storage.

e. No treated water storage shall be located beneath the filter pipe gallery.

f. Finished water shall not be stored or conveyed in a compartment adjacent to untreated or partially treated water where the two compartments are separated by a single wall.

g. Hydropneumatic or pressurized storage tanks shall be located above normal ground surface and be completely housed.

3. MATERIALS – Applicable AWWA Standards should be followed for materials used in water storage facilities. Other materials of construction may be acceptable when properly designed to meet the requirements of this chapter. The use of plastic tanks, translucent in particular, for outdoor storage of drinking water is not recommended.

4. FOUNDATION

a. Foundations for elevated storage tanks, standpipes, and reservoirs must be designed and constructed to ensure uniform support and minimal structural settlement. Unequal settlement impacts the distribution of stresses in the structure and may cause leakage, buckling, or otherwise impair the structural integrity of the tank, standpipe, or reservoir.

b. The ultimate bearing capacity of the soil shall be determined based on sound principles of geotechnical engineering in conjunction with a properly conducted soil investigation by a qualified geotechnical engineer. The design soil-bearing pressure shall be derived from the ultimate bearing capacity by the application of an appropriate factor of safety.

5. SIZING

a. BACKWASH WATER SUPPLY STORAGE – When sizing backwash water supply storage and its delivery, consideration must be given to the backwashing of several filters in rapid succession or the possibility of backwashing two or more filters at a time. The quantity of water required per filter will depend upon the filter backwash rate and the duration of the backwash cycle as described in Chapter V, Subsection J.9. Filter backwash water supply storage for all backwash systems shall be designed as finished water storage and be protected from sources of contamination such as backflow from a filter and cross-connection with a non-potable source.

b. CLEARWELL – Clearwell (and distribution system) storage shall be sized to relieve the filters from having to meet peak fluctuations in water demand.

c. DISTRIBUTION STORAGE – At a minimum, distribution system storage capacity shall be designed to equalize hourly variations in daily water demand, limit fluctuations in distribution system pressure, and provide reserve storage for fire protection, power outages and other emergencies. (In the absence of meter data, peak hourly flow can be assumed to be equal to twice the maximum daily flow or four times the average daily flow.) The minimum storage capacity for systems not providing fire protection e.g., rural water districts, may be reduced when the source waters and the treatment facilities have sufficient capacity with standby power capability to supplement system peak demands. For either situation, the system shall have the capability of replenishing its distribution system storage capacity each night and during low demand periods.

The maximum variation between high and low levels in storage structures providing pressure to a public water supply distribution system should not exceed 40 ft. (12 m). The minimum pressure in the distribution system shall be 20 psi (140 kPa) at ground level at all points in the distribution system under all flow conditions (KAR 28-15-18(e)). The normal working pressure should be approximately 60 psi (410 kPa). Pressure-reducing devices should be provided on mains in the distribution system or on individual service lines when static pressures exceed 100 psi (690 kPa). In some cases, establishing different distribution system pressure zones may be the most appropriate way to meet these requirements. Additional discussion regarding distribution system pressure may be found in Subsections A.1 and B.5 of Chapter VIII.

d. PRESSURE TANKS – Hydropneumatic tanks, when provided as the only means of storage, are acceptable only in very small water supply systems. Ground or elevated storage should be provided when serving more than 150 living units. Pressure tank storage is not to be considered as being available for fire protection services. Pressure tanks shall meet applicable ASME requirements or equivalent requirements of state and local laws and regulations for the construction and installation of unfired pressure vessels (ASME, 2004).

Small PWSSs using wells and pressure storage tanks should make the gross volume of the hydropneumatic tank at least 10 to 15 times the capacity of the largest pump (in gpm). Sizing of hydropneumatic tanks must also consider the need for adequate disinfectant contact time.

The proper air to liquid volume ratio should be determined to prevent excessive pump cycling for the normal operating pressure range of 40 to 60 psi (280 to 410 kPa). Well and pump capacities should be at least 10 times the average daily demand.

A minimum of two wells and two pumps shall be provided for a pressure storage tank system. A duplicate pressure tank or bypass piping is required to facilitate maintenance of the hydropneumatic system.

e. PRESSURIZED SYSTEMS – Pump pressurized distribution systems without storage will not be approved.

6. ROOF AND SIDEWALL – All finished water storage structures shall have suitable watertight roofs or covers that exclude birds, animals, insects, and excessive dust. The roof or cover of the storage structure shall be watertight with no openings except properly constructed vents, manways, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow (KAR 28-15-18(g)).

a. All pipes running through the roof or sidewall of a finished water storage structure shall be welded or properly gasketed where the tank is metal, or connected to standard wall castings which were poured in place during the forming of a concrete structure. These wall castings should have seepage rings imbedded in the concrete. Raw water lines or drains shall not pass through a finished water structure.

b. Openings in a storage structure roof or top, designed to accommodate control apparatus or pump columns, shall be curbed and sleeved with proper additional shielding to prevent the access of surface water to the structure. Where a cover is provided, a hasp and lock or other equivalent means of securing the cover shall be provided.

c. Valves and controls shall be located outside the storage structure so that valve stems and similar projections will not pass through the roof or top of the reservoir and the reservoir will not be subject to contamination by surface water.

d. The roof or cover for the storage structure shall be well drained, but downspout pipes shall not enter or pass through the reservoir. Parapets, or similar construction which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided. The roof of a concrete reservoir with earthen cover shall be both sloped to facilitate drainage and covered by an impervious membrane to protect it from contamination. Additional measures to protect the reservoir from contamination shall be employed where necessary and as approved.

e. All indoor finished water storage structures shall have an integral roof or cover as outlined above. Partially or fully open finished water storage structures located within a partially or fully enclosed building structure will not be approved.

f. Storage reservoirs with pre-cast concrete roof structures will not be approved.

g. Storage structure condensate collection system drain lines shall be drained to ground level. Direct or indirect drainage of a condensate collection system to an overflow will not be approved.

7. OVERFLOW – All water storage structures shall be provided with an overflow that is brought down to an elevation between 1 and 2 ft. (0.3 and 0.6 m) above the ground surface and discharges over a drainage inlet structure or a splash plate. No overflow may be connected directly to any type of a sewer or a storm drain, drain piping or drain structure. All overflow pipes shall be located so that any discharge is visible.

a. When an internal overflow pipe is used on an elevated tank, it should be located in the access tube. For vertical drops on the other types of storage facilities, the overflow pipe should be located on the outside of the structure.

b. The overflow for a ground level or elevated storage structure shall open downward and be screened with a non-corrodible screen with 0.25 inch (0.64 cm) openings installed within the pipe at a location least susceptible to damage by vandalism, or the discharge of the overflow pipe shall be fitted with a self-closing flap gate having an integral screen.

c. The overflow pipe shall be of sufficient diameter to permit the waste of water in excess of the filling rate.

8. VENTS – Finished water storage structures shall be vented. Overflows shall not be considered as vents nor should they be connected to vent piping. Open construction between the sidewall and roof will not be approved. In general, vents shall incorporate a fail-safe feature such as a screen that lifts when the tank empties at a rapid rate so that air can enter the vent pipe unrestricted. In addition, they shall prevent the entrance of surface water and rainwater, and exclude birds, animals, insects, rain, and dust by vent caps or other means. Vents for elevated storage tanks and standpipes shall be screened with 16-mesh non-corrodible screen. Vent construction for ground level storage structures should consist of an inverted "U" having an opening that is 2 to 3 ft. (0.6 to 0.9 m) above the roof or sod and is covered with 24-mesh non-corrodible screen installed within the pipe at a location least susceptible to vandalism.

9. LEVEL CONTROLS – Adequate controls shall be provided to maintain levels in distribution system storage structures. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment. Altitude valves or equivalent devices are desirable when multiple elevated tanks exist. Overflow and low-level warning or alarms should be located where they will be under responsible surveillance 24 hours a day.

B. OTHER CONSIDERATIONS

1. ACCESS – Finished water storage structures shall be designed for convenient access to the tank interior for cleaning, maintenance, and sampling. Manways above the water line on ground level and elevated storage tanks shall be framed at least 4 inches (10.2 cm) and preferably 6 inches (15.2 cm) above the surface of the tank roof at the opening. Manways on underground or earth-covered storage structures should be elevated 2 to 3 ft. (0.6 to 0.9 m) above the top of the structure or covering sod, whichever is higher. Manways shall be fitted with a solid watertight cover that overlaps the framed opening, extends down around the frame at least 2 inches (5.1 cm), is hinged at one side, and has a locking device. Manways below water line on ground level storage tanks should be located 2 to 3 ft. (0.6 to 0.9 m) above the elevation of the tank bottom. Manways shall be fitted with a solid watertight cover which overlaps the framed opening and overlaps the frame at least 2 inches (5.1 cm), be hinged at one side, and have a locking device. All entryways shall be gasketed to be watertight.

2. BASINS AND WET WELLS – Post-filtration disinfection contact basins, receiving basins, transfer wells and pump wet wells for finished water shall be designed as finished water storage structures.

3. DRAIN – Storage structures that provide pressure directly to the distribution system shall be designed so they can be isolated from the distribution system and drained for cleaning or maintenance without loss of pressure in the distribution system. The drain shall discharge to the ground surface with no direct connection to a sewer or storm drain.

4. FIRE PROTECTION – Elevated storage facilities shall have adequate clearance from buildings or other combustibles, or shall be fire-proofed.

5. FREEZING – All finished water storage structures and their appurtenances, especially the riser pipes, overflows, and vents shall be designed to prevent freezing which will interfere with proper functioning. Consideration should be given to heating and/or insulation of exposed pipes and valves.

6. GRADING – The area surrounding a ground level structure shall be graded to prevent surface water from standing within 50 ft. (15 m) of the structure.

7. INTERNAL CATWALK – Walkways over finished water in a storage structure will not be approved by KDHE.

8. PAINTING AND/OR CATHODIC PROTECTION – Proper protection shall be given to metal surfaces by paints or other protective coatings, by cathodic protective devices, or by both. All interior coatings or paints must be certified as meeting NSF International's ANSI/NSF standards for potable water, or equivalent, applied in

conformance with the manufacturer's recommendations, and protect public health and the environment (KAR 28-15-18(h)). After curing, the coating or coating system shall not transfer any toxic or taste and odor causing substances to the water. Prior to placing a tank in service, an analysis for VOCs is advisable to establish that the coating is properly cured.

Coating the interior of a previously uncoated storage tank with a wax coating will not be approved. Recoating the interior of a storage tank previously coated with a wax system is discouraged. However, when recoating the interior of a previously coated storage tank with a wax system is unavoidable, the old wax coating must be completely removed prior to the application of the new wax coating.

Cathodic protection should be designed and installed by competent technical personnel. A maintenance contract should be provided.

9. SAFETY – The safety of employees shall be considered in the design of storage structures. As a minimum, such structures and their appurtenances should conform to all pertinent laws, including local regulations. Ladders, ladder guards, balcony railings, and located entrance hatches shall be provided where applicable. Elevated tanks with riser pipes over 8 inches (20.3 cm) in diameter shall have protective bars over the riser openings inside the tank. Railings or handholds shall be provided on elevated tanks where persons must transfer from the access tube to the water compartment.

10. SECURITY – Fencing, locking devices on access manways, and other necessary precautions shall be provided to deter trespassing, vandalism and sabotage.

11. SILT PROTECTION – Discharge pipes shall be located to prevent silt from entering the distribution system. Removable silt stops are required.

12. DISINFECTION

    a. RE-CHLORINATION – Re-chlorination will be required if the disinfectant residual in the distribution system must be augmented in order to maintain an acceptable disinfectant residual at the ends of the distribution system. Re-chlorination system designs must be accompanied by calculations and data demonstrating that an adequate disinfectant residual will be maintained at the ends of a public water supply system's distribution system, and also at the ends of the distribution systems of those consecutive public water supply systems which do not re-chlorinate.

    b. MAINTENANCE AND REPAIR – All new, repaired, or repainted reservoirs must be flushed and disinfected (KAR 28-15-18(d)) according to applicable AWWA Standards before being placed into service with the exception that disinfection by Method 3 of section 4.3 of AWWA Standard C652 is not

allowed. Two or more successive sets of samples, taken at 24-hour intervals, shall indicate microbiologically satisfactory water before the facilities are placed into operation.

Disposal of heavily chlorinated water from tank disinfection processes shall be in accordance with KDHE requirements (Appendix D).

13. PRESSURE TANKS – Each tank shall have an access manway, a drain, and control equipment consisting of pressure gauge, water sight glass, automatic or manual air blow-off, means for adding air, and pressure-operated start/stop controls for the pumps. Where practical, the access manway should be 2 ft. (0.6 m) in diameter.

14. WATER CIRCULATION – Include in all reservoir designs provisions to ensure adequate water circulation. Baffling or placement of inlets and outlets may be employed to promote circulation in underground or ground level reservoirs. Inlets and outlets for these types of reservoirs should be located on opposite sides of the reservoir with the outlets being located near the floor.

    While the physical nature of standpipes and elevated storage tanks may limit placement of separate or combined inlets and outlets, their respective geometries in combination with appropriately sized pipe can produce flow velocities that will promote water circulation. In addition, internal distribution piping may be utilized to further promote water circulation.

15. MAINTENANCE/INSPECTION – It is recommended that a maintenance and inspection program for all storage structures be implemented and followed as part of the system's approach to managing and protecting the quality of its drinking water. When possible, at least one other reservoir shall be available for storage during the outage of any one storage structure. Storage structures should be drained, cleaned and inspected every two years.