


TN Department of
Environment &
Conservation



Storage Tanks

CSUS: Water Distribution Systems
AWWA: Water Transmission and Distribution

(1)

Objectives

- Purpose and Types Water Storage
- Water Storage Facilities
- Inspections and Maintenance
- Disinfection

Purpose of Water Storage

- Equalizing supply and demand
- Increasing operating convenience
- Leveling out pumping requirements
- Decreasing power costs



(3)

Purpose of Water Storage



- Providing water during power or pump failure
- Providing adequate water for fire fighting
- Providing surge relief
- Increasing detention times
- Blending water sources
- Decrease pumping costs

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Capacity Requirements

- Based on maximum water demands in different parts of the system
- Too much storage can cause stagnant water and taste & odor problems
 - 20% turnover rate to prevent it from becoming septic within 24 hours
 - less sediment

(5)

Type of Service

- Operating Storage
 - Tank directly connected to distribution piping
 - Fills and empties based on system pressure
- Emergency Storage
 - Used for emergency, e.g. fire protection
 - Not suitable for potable use
 - Subject to freezing due to lack of circulation

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WATER STORAGE FACILITIES

Configuration of Storage Tanks

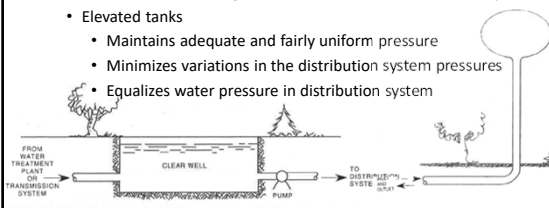


- Elevated Tanks
- Ground-Level Reservoirs
- Standpipes
- Hydropneumatic Tanks
- Surge Tanks

(8)

Storage Facilities

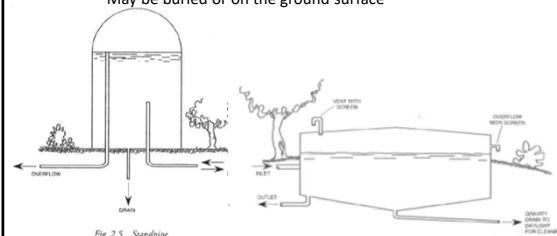
- Provide a sufficient amount of water to average or equalize the daily demands
- Fire protection, industrial uses, reserve storage
- Types
 - Clear wells
 - Used for the storage of filtered water from a treatment plant
 - Elevated tanks
 - Maintains adequate and fairly uniform pressure
 - Minimizes variations in the distribution system pressures
 - Equalizes water pressure in distribution system



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Storage Facilities

- Types
 - Standpipes
 - Stand on ground and have a height greater than diameter
 - Ground-level reservoirs
 - May be buried or on the ground surface



(10)

Ground-Level Reservoirs

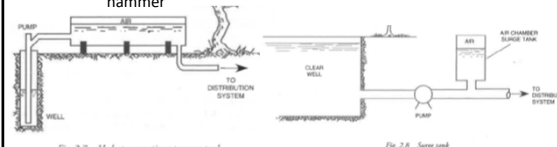


This is an old open-topped reservoir that has been converted with a liner-cover

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Storage Facilities

- Types
 - Hydropneumatic or pressure tanks
 - A system in which a water pump is controlled by the air pressure in a tank partially filled with water
 - Must contain proper air to water ratio: 2/3 water to 1/3 air
 - **Insufficient air will cause pump to "short cycle"**
 - Surge tanks
 - Used to control water hammer or regulate flow of water
 - Should be located close to activity that may cause water hammer



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Storage Facilities – Elevated Tanks

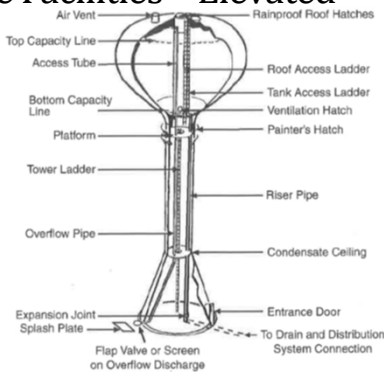


FIGURE 3-9 Principal accessories for an elevated storage tank
Courtesy of CB&I

Storage Facilities – Elevated Tanks

- Same pipe used for inlet and outlet called a riser
- Overflow pipe required in case water-level controls fail
 - Should be covered by weighted flap valve and **24 mesh non-corrodible screen**
- Must be furnished with drain connection to empty tank for maintenance and inspection
- Water level in tank monitored by either pressure sensor at base or level sensor inside tank
 - Telemetry equipment, altitude valves, overflow and low-level alarms
- Must be furnished with valve a connection to distribution system
- Altitude valve required if tank is not tall enough to accept full system pressure without overflowing
 - Automatically shuts off flow to tank when water level reaches overflow point

Storage Facilities – Elevated Tanks

- Access hatches must allow for entry and ventilation during maintenance and inspections
 - Hatches on roof must have rims under cover to prevent surface runoff entering the tank
 - Hatches at bottom must be able to withstand pressure of water column
- Multicolumn tanks generally have three ladders
 - One up a leg of tank to a balcony, one from balcony to roof, one installed on the roof
- Vents must be installed to allow air to enter and leave the tank as the water level changes
 - **4 mesh non-corrodible screen required**

Storage Tank Collapse

White City, Oregon

- Caused by massive leak in 42 inch water main (50,000 gallon per minute) which quickly drained the tank
- Vacuum formed sucking in the roof



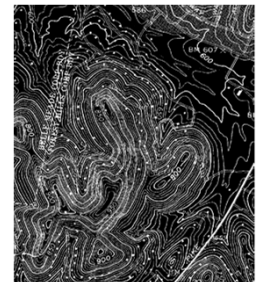
Storage Facilities – Elevated Tanks

- Interior and exterior coatings must be able to withstand harsh conditions
 - Exterior coatings must maintain a good appearance over a reasonable period of time
 - All paints must be acceptable to FDA and EPA for contact with potable water
- Cathodic protection reverses flow of current that dissolves iron and causes rust and corrosion
 - Should be used in conjunction with tank coatings
- FAA may require installation of obstruction lighting or strobe lights



Selection and Location of Storage

- Determined by hydraulics, water demand, elevation of terrain, purpose of tank, etc.
- Type of storage depends on purpose of tank



Storage Facility Operations

- Supply water during high demand
 - Low demand times are used to fill the tank
- May use variation of pumps to maintain pressure in distribution system
 - Can be controlled automatically by instrumentation
 - Automated systems must be inspected regularly
- Abnormal operating conditions
 - Excessive water demands
 - Broke or out of service pumps, mains, or tanks
 - Stale water leading to taste and odor problems

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Storage Levels

- Water levels drop during peak demands and rise during low demands
- Water demands vary within the day, from day to day, and from season to season
 - Knowing these patterns, the operator can anticipate high-demand periods
- Automatic water level regulation can be achieved using altitude-control valves
 - A valve that automatically shuts off the flow into an elevated tank when the water level in the tank reaches a predetermined level
 - Prevent overflows
 - Maintains a constant water level based on system pressure

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Storage Level Controls

- Electrodes mounted at various levels in tank sense the change in water level and can start/stop the pump as needed
 - Can be difficult to reach for maintenance and replacement
 - Susceptible to corrosion or contamination
- Ultrasonic transmitters send a continuous sound wave to a receiver; when covered with water, the signal is broken
- Pressure switches respond to changes in water pressure
 - Must be properly calibrated
- Solid-state electronic sensors measure the actual water surface level
- Differential-pressure altitude valves can regulate water surface levels based on pressure

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INSPECTIONS AND MAINTENANCE

Facility Inspection

- Routine inspections part of normal, daily routine
 - Include check of security items
- Periodic inspections include climbing and looking inside
 - Check security items, site drainage, penetrations into the system, and overflows
- Comprehensive inspection must be performed by professional every 5 years
 - Retain record for minimum of 5 years

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Tank Inspections



- Must be professionally inspected every 5 years in accordance with State requirements (Rule 33)
 - Inspected by draining or by using a diver
 - Inspected by a third party

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Facility Inspection

- Wet inspections conducted by divers or robots allow tank to remain filled
 - Higher chlorine residual required during inspection as well as a cleaning process to protect against bacterial contamination
 - Divers and equipment should be disinfected with 200 mg/L chlorine solution before entering tank
 - Divers equipped with surface supplied air, drysuit, and surface supplied equipment
 - Refer to AWWA C652 Sec 4.4 for more information

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Pumps

- Centrifugal pumps must be primed
- Primed – filling a pump casing with water to remove the air
 - Primer pump will pump water into the pump casing to submerge the impeller
 - Priming water tank or auxiliary water supply can be used to add water to the pump casing bleeding off the air in the casing
 - Electric or hand-operated cause water to flow into the suction pipe and pump casing
- Foot valve – check valve located at bottom end of the suction pipe on a pump
 - Holds pumps prime

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Troubleshooting

- Water Quality Problems
 - Microbiological
 - Loss of chlorine residual
 - Bacterial growth
 - Chemical
 - Leaching of chemicals from linings and coatings
 - Physical
 - Settling and collection of sediment, rust & chemical precipitate

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Maintenance

- Three types:
 - **Preventive** – repair or adjustment of equipment and facilities that is done before deterioration takes place
 - **Predictive** – attempts to predict when a failure might occur
 - **Corrective** (repair) – maintenance that is necessary when a problem already exists
- Painting
 - Paints and coatings accepted by the Environmental Protection Agency (EPA) and/or the National Sanitation Foundation (NSF) for potable water contact are generally acceptable to the Department

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Corrosion Control

- Factors affecting corrosion
 - Warmer water = increased corrosion
 - Water velocity
 - High velocities in corrosive water will lead to rapid pipe deterioration
 - Low velocities lead to longer contact times and metal pickup (red or dirty water complaints)
 - Dissolved oxygen increases = increased corrosion
 - **Carbon dioxide increases = increased corrosion**
 - CO₂ lowers pH
 - Dissolved minerals increase = increased corrosion
 - Sulfate reducing bacteria = increased corrosion

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Corrosion Control

- A coat of paint is the least expensive type of corrosion control
- Metallic coatings such as zinc
- Nonmetallic coatings
- Chemicals added during treatment of water to deposit a protective coating or film on the tanks metal
 - Calcium hydroxide (lime), sodium carbonate (soda ash), zinc paints
- Cathodic protection - electrical system for prevention of rust, corrosion, and pitting of metal surfaces that in contact with water or soil
 - Direct current applied to electrodes will cause them to corrode or be “sacrificed”

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DISINFECTION

Disinfection

- Disinfection is the inactivation/destruction of disease-causing organisms
- New storage facilities and those that have been repaired, cleaned, or had cathodic protection installed must be disinfected
- Follow AWWA Standard C-652, Disinfection of Water-Storage Facilities
- Always wear protective clothing
- Anyone entering tank must have on a safety harness
- Never enter a tank without two people standing by for rescue purposes

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Disinfection

- Liquid chlorine – Cl_2
 - 100% pure
- Sodium hypochlorite – NaOCl
 - Bleach
 - 5-15% pure
- Calcium hypochlorite – $\text{Ca}(\text{OCl})_2$
 - HTH (high test hypochlorite)
 - 65% pure

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Disinfection – AWWA C652

Method 1

- Fill tank to overflow level with potable water
 - Must have 10 mg/L at end of contact period
- Liquid chlorine/sodium hypochlorite
 - Add to the water during filling operation to give a uniform chlorine concentration
- Calcium hypochlorite
 - Crushed to not larger than $\frac{1}{4}$ inch and poured into tank before filling
- Retention period
 - Liquid chlorine – 6 hours
 - Hypochlorite – 24 hours

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Disinfection – AWWA C652

Method 2

- 200 mg/L chlorine applied directly to surface of all parts of tank that may come in contact with potable water
 - Sprayed or brushed on
 - Let sit for 30 minutes then fill tank to overflow

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Disinfection – AWWA C652

Method 3

- Fill 5% of tank with 50 mg/L chlorine solution
 - Hold for 6 hours
- Fill tank to overflow
 - Hold for 24 hours
 - Must have 2 mg/L at end of contact time

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Disinfection

- After disinfection, highly chlorinated water must be disposed of properly
 - Any water with concentration greater than 2 mg/L should be diluted or dechlorinated before disposal
- Do not discharge to sanitary sewer without first communicating with the wastewater treatment plant
- Chlorinated water should not be discharged to any surface waters with permission from the State
- After flushing, bacteriological testing must be performed and have negative results before putting tank in service

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Storage Facilities

- Inspections must be performed by third party every 5 years
 - Maintain record for 5 years
 - System operators should visually inspect tanks periodically
- Cleaning
 - Out-of-service cleaning consists of draining, washing, and disinfecting tank
 - In-service uses divers or remotely controlled equipment
- Booster pump is used to increase the pressure in the mains
 - Will not produce a negative pressure anywhere in the system
 - Pressure in suction line shall be maintained at or above 20 psi by the use of a pressure sustaining valve or low pressure cutoff device

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Ground Storage Tank Inspection Report

Job No.: _____ Date: _____ Inspector: _____

Tank owner: _____ Owner's order #: _____

Owner's representative: _____ Title: _____

Mailing address: _____

Physical address: _____

City, State: _____ Zip: _____

County tank is located: _____ Seismic zone of county: _____

Telephone: _____ Fax: _____

Location of tank: _____

Original Contractor #: _____ Year built: _____

Original Manufacturer: _____ Capacity: _____

Date of last inspection: _____

Diameter: _____ Height: _____

Type of construction: _____ Welded: _____ Riveted: _____

Who is customer's insurance carrier? _____

Storage Tank Vocabulary

- | | |
|-------------------------|--------------------------|
| A. Altitude Valve | H. Hydropneumatic System |
| B. Booster Disinfection | I. Overflow Level |
| C. Cathodic Protection | J. Reservoir |
| D. Elevated Storage | K. Riser |
| E. Elevated Tank | L. Standpipe |
| F. Emergency Storage | M. Tank |
| G. Ground-level tank | |

- _____ 1. An electrical system for preventing corrosion to metals, particularly metallic pipes and tanks.
- _____ 2. A system using an airtight tank in which air is compressed over water (separated from the air by a flexible diaphragm). The air imparts pressure to water in the tank and the attached distribution pipelines.
- _____ 3. A structure used in a water system to contain large volumes of water or other liquids.
- _____ 4. The maximum height that water or liquid will rise in a receptacle before it flows over the overflow rim.
- _____ 5. A valve that automatically shuts off water flow when the water level in an elevated tank reaches a preset elevation then opens again when the pressure on the system side is less than that on the tank side.
- _____ 6. Storage volume reserved for catastrophic situations, such as supply-line break or pump-station failure.
- _____ 7. (a) Any tank or basin used for the storage of water. (b) A ground-level storage tank for which the diameter is greater than the height.
- _____ 8. A ground-level water storage tank for which the height is greater than the diameter.
- _____ 9. In the distribution system, storage of water in a tank whose bottom is at or below the surface of the ground.
- _____ 10. In any distribution system, storage of water in a tank supported on a tower above the surface of the ground.
- _____ 11. The vertical supply pipe to an elevated tank.
- _____ 12. A water distribution storage tank that is raised above the ground and supported by posts or columns.
- _____ 13. The practice of adding additional disinfectant in the distribution system.

Storage Tank Review Questions

1. List 9 reasons for providing water storage in a distribution system.
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2. List the 4 types of distribution storage tanks and a description of each.
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3. What is the difference between operating storage and emergency storage?
4. Why should vent openings on storage tanks be screened?
5. What is the purpose of an altitude valve?
6. How often must storage tanks be inspected according to the Regulations for Public Water Systems and Drinking Water Quality for the State of Tennessee?

7. After disinfection, what must be done before a tank is put back in service?
8. Name four things that should be considered when determining the type and the site for a new storage tank.
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9. Why should the overflow pipe on a storage tank never be directly connected to a sewer or storm drain?
10. How are storage tanks protected from corrosion?

Storage Tank Review Questions

1.
 - Equalizing pressure and demand
 - Increasing operating convenience
 - Leveling out pumping requirements
 - Decreasing power costs
 - Providing water during source or power failure
 - Providing adequate water for fire fighting
 - Providing surge relief
 - Increasing detention time
 - Blending water source
2.
 - Elevated – tank on tower, provides pressure, minimizes pressure variations
 - Standpipe – tank on ground, taller than diameter, stores large volumes of water at low pressure, safer than elevated tank, may require pump
 - Ground-level reservoir – diameter greater than height, requires pump
 - Hydro-pneumatic – 2/3 water, 1/3 air; air helps maintain pressure, usually used with wells; small tanks
3. Emergency storage is not considered to be potable water – for emergencies only, e.g. fire protection.
Operating storage is directly connected to distribution system, fills and empties by distribution pressure.
4. To keep out birds, insects, animals, etc.
5. To keep tank from overflowing
6. Professionally every 5 years
7. Bacteriological samples must be taken and must pass.
8. Water demand; Hydraulics, terrain; Purpose of tank; Public opinion
9. That would be a cross connection
10. Cathodic protection, coatings

Storage Tank Vocabulary

- | | |
|------|-------|
| 1. C | 8. L |
| 2. H | 9. G |
| 3. M | 10. D |
| 4. I | 11. K |
| 5. A | 12. E |
| 6. F | 13. B |
| 7. J | |

