

Water Tank Design and Maintenance

Notes for Class # 6 Web site

http://water.me.vccs.edu/courses/env110/Lesson10_print.htm

Types of Water Tanks

Introduction

Water can be pumped into the tank during periods of low demand and then pumped out of the tank into the distribution system during periods of peak demand. In addition, storage tanks can provide the water pressure in the distribution system.

The two types of storage tanks are ground level tanks and elevated tanks. Elevated storage facilities are also divided into two types - standpipes and tanks

Ground Tanks

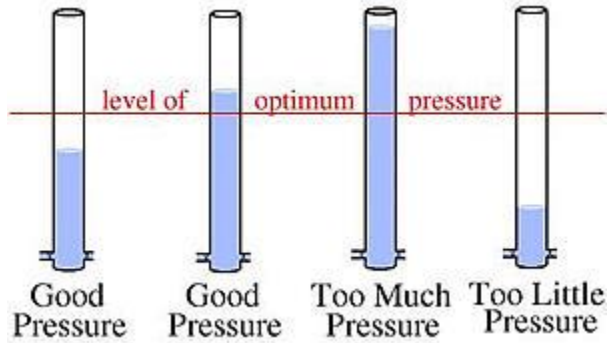
However, in many cases, water is stored in reservoirs located at ground level due to a lower initial cost of construction, a lower maintenance cost, the ease with which water quality can be tested, greater safety, and a greater aesthetic value.

The primary disadvantage of a ground tank is a lack of water pressure. Any pressure in a ground tank must be maintained through directly pumping the water. The continuous pumping can be costly and also means that water pressure in the distribution system will drop if the pumps have to be shut down.

Elevated Tanks

Elevated tanks do not require the continuous operation of pumps. Short term pump shutdown does not affect water pressure in the distribution system since the pressure is maintained by gravity. And strategic location of the tank can equalize water pressures in the distribution system. However, precise water pressure can be difficult to manage in some elevated tanks.

The pressure of the water flowing out of an elevated tank depends on the depth of the water in the tank. A nearly empty tank probably will not provide enough pressure while a completely full tank may provide too much pressure. The optimal pressure is achieved at only one depth.



The optimal depth of water for the purpose of producing pressure is even more specific for standpipes than for tanks elevated on legs. The length of the standpipe causes continual and highly unequal pressures on the distribution system. In addition, a significant quantity of the water in a standpipe is required to produce the necessary water pressure. The water below a certain level is therefore used only as a support, unless booster pumps are available for emergency use of this water.

Tank Design

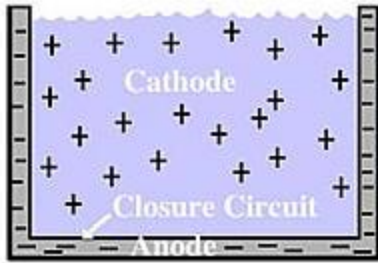
When designing an elevated tank, the required elevation and the size and shape of structural members (legs, etc.) must also be taken into account.

Capacity, or the volume of water which a tank can hold, is one of the most important design factors. The capacity can be determined through an analysis known as a "mass diagram" or through a graphical solution based on a study of hourly pumping. The graphical solution takes into account the peak water demand for one hour each day. Based on this peak hourly demand, a rate of demand can be calculated. The required capacity of the water tank will, in turn, depend on the calculated rate of demand and on an estimate of the future population of the area.

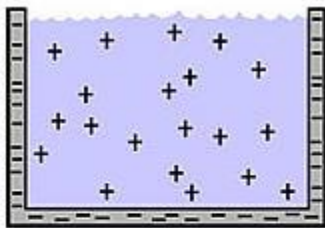
Corrosion Control

Corrosion

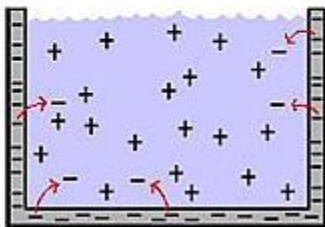
Corrosion is another word for rust, the breakdown of metal. In a water tank, corrosion is due to an electrochemical reaction. An electrical current flows through the water from one point on the water tank's inner surface to another. The flow of the current results in corrosion of the tank's surface as some of the metal dissolves into the water. An ampere of current flow in a water tank over a year's time can result in 20 to 24 pounds of steel being taken into solution.



A corroding water tank works in the same way as a battery. A battery has an anode and a cathode. The anode is an area which gives off electrons (negatively charged particles which make up a current.) The electrons flow from the negatively charged anode (-) to the positively charged cathode (+). In order to flow from the anode to the cathode, electrons must pass through what is called a closure circuit or an electrolyte, a substance which forms a bridge between the anode and cathode.



The electrons (-) in the steel tank...



Move into the water, causing corrosion.

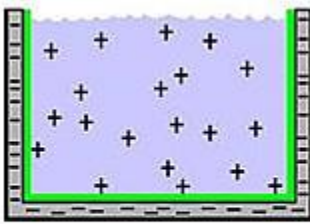
In a water tank, the steel wall of the tank is the anode. It gives off electrons which flow into the water. The water is the cathode and the surface of the tank is the closure circuit which connects the anode and cathode. As the electrons flow out of the steel wall of the tank, the tank corrodes. Over time, this corrosion can discolor the water and can result in leaks in the tank wall.

Corrosion of a tank is prevented in two ways. The inner wall of the tank can be coated with paint, which forms a physical barrier between cathode and anode and prevents the electrons from

moving out of the steel wall. Corrosion can also be prevented by cathodic protection which introduces electrical currents from external sources to counteract the normal corrosion reactions. Both methods of corrosion control will be explained below.

Coatings

The most common method of corrosion control is coating the tank wall with paint. The coating of paint forms a physical barrier between the tank wall and the water. As a result, electrons cannot flow from the tank wall into the water and the tank wall does not corrode.



Coatings form a physical barrier between the cathode and the anode.

Coatings will perform well in the majority of atmospheres. However, the coating should match the design of the facility in type and application and should be properly inspected. The American Water Works Association (AWWA) has standard specifications for maintenance and painting of storage facilities, including a list of coatings for interior and exterior surfaces.

The coating must be repaired at regular intervals as part of the regular maintenance of the tank. Coatings fail when the protective barrier is broken or when the dielectric strength is not sufficient to withstand the electrical-driving force of the corrosion cell.

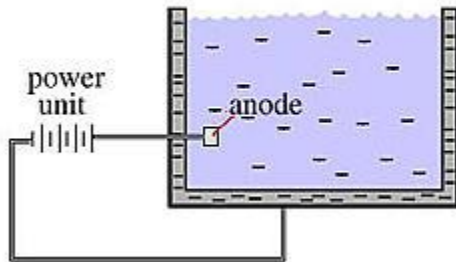
Breaks may be caused by a variety of circumstances. The paint may be too thin or may have degraded through proximity to the environment. The coating may be porous and may not form a complete barrier. Or the paint may have been applied incompletely or improperly. If the surface was not properly cleaned before applying the paint, then breaks will occur since the paint will not adhere well to contaminated surfaces or to blisters. The procedure used to repair breaks in the coating will be discussed later in the section on maintenance.

Cathodic Protection

The other type of protection from corrosion, cathodic protection, has been in use since the mid-1930s. Cathodic protection systems now protect hundreds of thousands of miles of pipe and acres of steel buried in the ground or immersed in water.

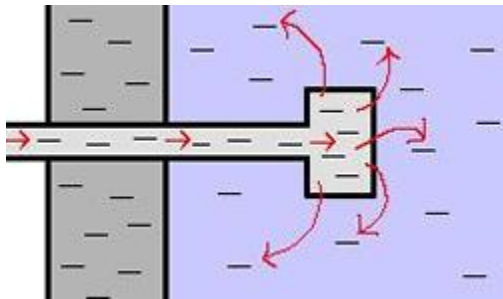
Since the first cathodic protection system was invented, fully automatic and error-free cathodic protection systems have been developed. These systems both control corrosion and increase the life of the coating systems. The modern, automatic systems do not require the operator to adjust the system for changing conditions, such as varying water levels, temperature, and coating effectiveness. Instead, the automatic system will automatically compensate for these changes.

Cathodic Protection:



A cathodic protection system consists of a power unit, an anode, and wiring between the power unit and anode and between the tank wall and the power unit, as shown above.

The power unit is a direct current source, meaning that it converts electricity from alternating current to direct current, producing a continuous flow of electrons. The electrons are fed along a wire to an anode in the water tank. The anode disperses the electrons into the water, changing the potential of the water from positive to negative.



Since the water now has a negative potential, just like the metal of the tank walls, electrons do not flow out of the tank walls into the water. Instead, the electrons from the water flow into the tank walls and then along a wire back to the power source, completing the circuit.

In essence, the cathodic protection system has created a new corrosion battery. With the addition of the anode attached to the power source, the tank walls have become cathodes which take up, rather than lose, electrons. If the cathodic protection system is properly controlled, the surface of the tank will remain corrosion-free. Corrosion occurs only in the new anode, which is easily replaceable and relatively inexpensive.

Commonly used materials for the anodes in the cathodic protection system are cast iron alloyed with 14.5% silicon, aluminum and platinum wire, and ribbon forms. When water tanks are not prone to freezing, cast iron and other long-life anodes are most commonly used.

As with most other components of water systems, many factors must be considered when deciding on a cathodic protection system. The dimensions of the structure to be protected, the coating, and the water characteristics all factor into the type of system to be used. The manufacturer's representative will consider these factors and choose a system which will achieve full corrosion control without providing costly over-protection. A reliable company should be used which specializes in cathodic protection and which has a service organization within one day's travel time of the tank's location. When buying a cathodic protection system, a service agreement should also be considered.

Advantages and Disadvantages

Cathodic protection systems are an economic alternative to periodic repainting and the associated downtime for repair. The systems are being used quite extensively and have proved to be dependable when appropriately sized, installed, and maintained.

However, cathodic protection systems will only protect the area of the tank interior where the water comes in direct contact with the metal tank wall. The area of the tank above the water line will not be protected and can still corrode. In addition, the bottom of tanks are usually covered with silt, debris, and sand of varying depths. The tank bottom below this debris covering will not be protected unless the covering is removed before installing the cathodic protection system.

Coatings and cathodic protection have often stood on opposite sides of a fence as exclusive and opposing approaches to corrosion protection. Proponents of coatings often discount the advantages of cathodic protection and claim that a good, well-applied coating is the only necessary protection for steel. On the other hand, proponents of cathodic protection systems claim that any immersed or buried metal structure can best be protected by a well-engineered cathodic protection installation. Under many conditions, both sides may be correct in their assertions. However, under many more commonly occurring conditions, the ideal corrosion protection is actually a combination of both protection concepts.

Maintenance

Purpose of Tank Maintenance

Every water tank must be periodically maintained in order to ensure long life of the tank and quality water within the tank. Some tanks, such as the reinforced concrete tanks often used for

ground level or standpipe reservoirs, have lower maintenance costs over the life of the structure when compared with steel tanks. But all types of tanks require at least some maintenance.

Maintenance can be considered a cost-saving measure. Periodic maintenance is usually much cheaper than the large repairs which will be necessary in un-maintained tanks. The cost of inspection is an insurance policy against premature failure of the tank.

The tank's paint coating requires the most maintenance since it must be replaced periodically. When the coating is not well maintained, the tank will have to be repaired. Repair will usually cost two and a half times more than the cost of the original coating.

In addition to the financial cost associated with replacing badly maintained coats of paint, the coatings applied on such surfaces are usually lower in quality due to adverse application conditions. Seventy five percent of all coating failures are attributable to deficient surface preparation or to improper application of the paint. These failures lead to downtimes during which the tank cannot be used while it is being repaired. The downtime and loss of facility production can lead to potentially staggering costs.

Formal coating inspections and the associated maintenance will vastly increase the probability of achieving a successful coat application that will protect for the design life of the system. They will prevent costly repairs and are financially responsible in the long run.

Maintenance Inspection

Tanks must be inspected at intervals as the first step of the maintenance procedure. The purpose of the inspection is to determine if repairs are required and, if so, the exact nature and extent of the work required. Inspection of water tanks is expensive, but the cost is insignificant compared to the cost of premature failure of the tank.

A thorough inspection must be performed every two or three years on the entire structure. Some facilities choose to have annual inspections, as will be discussed later in this section. In addition, inspections should be performed during the construction of new water tanks and during any repair, painting, and disinfection.

In many cases, inspection is considered to be a non-essential part of the maintenance process. Inspectors are often hired only after there has been a costly premature failure in the tank coating.

In other cases, initial planning for coating jobs includes qualified coat inspections, but the inspection contract is dropped as a cost-saving measure. The firm contracted to apply the coating then monitors itself or the tank owner's personnel schedule spot inspections. This inspection technique usually results in improperly applied coatings which will result in tank failure.

Inspection should be considered a mandatory part of the maintenance procedure and should be conducted by an independent expert who will receive no benefit from any maintenance performed on the tank. In other words, if a tank is inspected by a painting contractor or a paint manufacturer, then the inspector will probably schedule more repaintings since he will benefit financially from each paint job. Such inspectors are not independent and should not be hired to perform inspections.

The inspector should be well trained by a qualified organization. A professional engineer (see the American Water Works Association Standard D 101) will be able to evaluate the structure, the grouting, the welds, the formulations, the structural alignment, the paint conditions (inside and out), the leakage, the rod adjustment, any settling, and successfully complete a corrosion evaluation in accordance with D 101. The AWWA Standard: *Painting Steel Water Storage Tanks* includes a brief section on inspection which should be followed but which is not adequate as a basis for the entire inspection.

The inspector should outline specific maintenance needed to restore the structure. This inspection should be the basis for all maintenance of the structure - only maintenance required by the inspector should be performed. In addition, a complete record of inspections and maintenance should be kept.

Following the proper guidelines and selecting a qualified engineer to perform regular inspections will help avoid serious maintenance problems in the future.

Preparing for Maintenance

Inspections determine the need for maintenance. Then the tank must be dewatered and the surface prepared for maintenance.

The first step during many maintenance procedures is to drain all of the water out of the tank. Before dewatering any potable water storage vessel, notice should be given to the state's Department of Environmental Management to allow time for any problems to be resolved by state and local officials. Insurance carriers should also be notified before dewatering and inspection occurs.

Next the structure must be prepared for maintenance. This preparation is a very important part of the process. If preparation is poor, the maintenance job will be poor. The interior and exterior surfaces must be cleaned of all rust scale, paint scale, blisters, rust, dirt, and growths. This cleaning can be achieved through any of several methods - using wire scrapers, sand blasting, flame cleaning, and so on.

After cleaning the surface, loose rivets must be replaced and damaged seams must be welded.

Painting

To prevent rust, painting should begin as soon as possible after the structure is cleaned and repaired. A coat of rust-inhibitive primer should be painted on all bare surfaces first. If the surface preparation resulted in an extensive removal of old paint, then the primer coat should cover the entire surface.

A protective coating should be applied on top of the primer coat. This protective coating is applied in a thickness ranging from five to fifteen thousandths of an inch and serves to protect the tank surface from the environment.

The protective coating is composed of a vehicle containing solvents, resins, pigment and inert ingredients. The pigments add color, but may also perform a variety of other functions. The pigments may provide resistance to the sun's ultraviolet light and may enhance the physical properties of the paint and the gloss.

Curing

The tank must be allowed to dry, or to cure, before being refilled with water and put back into service. The paint on the inside of the tank may take longer to cure, especially during the winter. Some types of paint, such as high build epoxies, will be problematic if applied during the winter. Instead, high solid vinyl should be used during these months since they will cure more reliably.

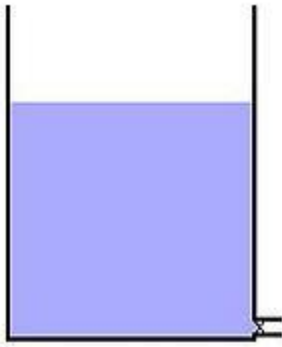
Sterilization

If a tank has been emptied for inspection, cleaning, painting, or for any other purpose, the tank must be thoroughly sterilized before being put back into service. Outside demands should never be allowed to force a tank back into service before it is properly cured and disinfected.

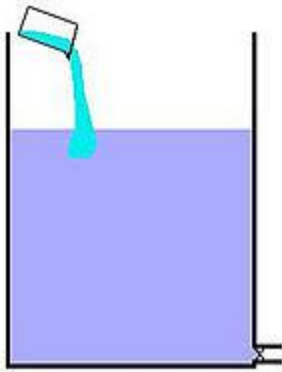
The structure should be thoroughly disinfected and chlorinated in accordance with Plumbing Codes before being used again. Bacteriological samples must be taken and approved and a copy of the report must be sent to the Health Department.

A suggested method for sterilizing a tank is explained below:

1. Fill the tank $1/2$ to $3/4$ of the way full of water.



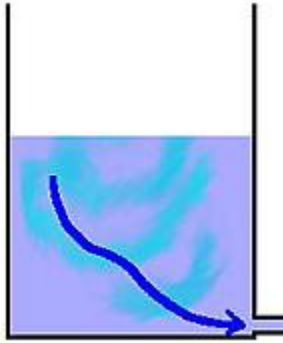
2. Mix the disinfectant into about ten gallons of water and pour into the tank. The amount of disinfectant to be added will depend on the capacity of the tank. You should add 12 pounds of HTH or Perchloron or 10 gallons of 10% sodium hypochlorite for each 20,000 gallons of water that the tank will hold. So, if you are disinfecting a 75,000 gallon tank, you can either add 45 pounds of HTH, 45 pounds of Perchloron, or 37.5 gallons of sodium hypochlorite.



3. Completely fill the tank with water. This will evenly mix the disinfectant into the water.



4. Permit the tank to stand for 24 hours if possible, but for no less than 6 hours



An alternative method may be used by experienced personnel:

1. Wash down all surfaces thoroughly.
2. Spray the bottom, side-walls, and top with a hypochlorite solution containing at least 200 ppm of chlorine. The person in the tank must take special precautions. He or she must wear an effective gas mask and must be roped to an attendant on the outside of the tank.
3. Fill the tank and collect samples for bacteriological analysis.

Annual Maintenance Service

Annual maintenance service contracts are an alternative to hiring an inspector to periodically inspect a water tank and recommend maintenance. Under this type of plan, a company is hired to clean the tank once a year, inspect the tank, and make all necessary repairs including painting, if necessary. In most plants, the entire tank is thoroughly cleaned and given a coat of paint every fifth year. Annual maintenance service contracts have become popular in municipalities with tanks and towers with capacities of less than 250,000 gallons. The company hired will often require that their own company restores the tank before entering into a contract for annual maintenance service. Then the company agrees to inspect and maintain the tank yearly for a set length of time, often for twenty years. Due to municipal changes, some companies will allow a municipality the right to cancel or renew the contract on a yearly basis on the anniversary date. Since the maintenance company will be given exclusive responsibility for the upkeep of the tank, great care should be taken in selecting such a company. The company must conduct work with integrity, honesty, and professionalism. In addition, Comprehensive Liability and Workmen's Compensation Insurance should be carried on each contract to ensure performance of

the maintenance work. The water works should also demand a corporate bond, not an individual bond.

If an honest, reliable contractor is selected to perform the work, then annual maintenance service contracts can be a good choice for the maintenance of water storage facilities.

Review

Water tanks can be divided into two types - ground tanks and elevated storage tanks. Each type of tank has advantages and disadvantages which should be considered when planning a new facility. In addition, other factors such as structural stability, equipment design, tank location, elevation, and capacity should all be taken into account.

Corrosion is a serious problem in water tanks. The metal walls break down due to an electrochemical reaction. Electrons flow from the walls of the tank (the anode) into the water (the cathode.) The third component of the corrosion battery is a closure circuit - a surface linking the anode and cathode through which electrons can flow. A paint coating protects against corrosion by forming a physical barrier between the anode and the cathode. The other type of protection, cathodic protection, provides a replacement anode so that the tank walls do not corrode. Each type of corrosion protection has advantages and disadvantages when used singly, and they can also be used in combination.

Tank maintenance is essential to prevent costly tank failure. The tank should be inspected by an independent inspector at least every two or three years. Some water works choose to hire an annual maintenance service to perform yearly inspections and maintenance. In either case, the inspector will determine what type of maintenance should be performed.

The first step during painting, a common maintenance procedure, is to empty the tank and clean the tank surface. Next, a primer coat should be applied and then a protective coat. Finally, the tank is cured and sterilized before being placed back into service.