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Many industrial facilities rely on elevated gravity tanks plus suction tanks and fire pumps for adequate fire protection water supply.

Fire Water Storage Tanks

The third installment of this series focuses on fire water tanks and provides a review of what should be included in a typical self-inspection program as it relates to tanks.

BY WALTER S. BEATTIE, CSP, CFPS, CSHM

Inspection, testing and maintenance of fire water storage tanks are critical to fire safety. Water tanks provide stored water for fire pumps and fire protection systems. The primary standard in use in most companies and municipalities is NFPA 25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems. NFPA 25 establishes minimum requirements for the periodic inspection, testing and maintenance of water-based fire protection systems. It is not an optimum standard. Rather, it is the minimum, and the level of action NFPA 25 requires is the base from which you should start and improve upon to meet your facility's needs.

Inspection, testing and maintenance of fire water storage tanks are critical to fire safety.

Many facilities I visit do not have an adequately documented inspection, maintenance and testing program in accordance with NFPA 25. Some do not keep written records of

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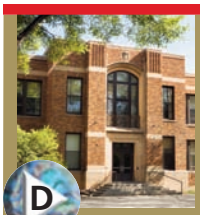

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Fire Water Storage Tanks

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inspections, while others conduct limited or no testing. A facility without a documented program does not meet NFPA 25's intent. The program must include documentation. If it is not documented, most authorities having jurisdiction (AHJs) will be skeptical that the activities have been completed.

A program that meets the minimums stated in NFPA 25 is an ongoing program, which typically requires weekly (and sometimes daily) interaction with the systems. It should not be a program that is solely carried out by a sprinkler contractor. You are ultimately responsible for your systems. You must familiarize staff with your facility's systems, and they should know what actions to take in the event of an emergency. It is unlikely that the sprinkler contractor will be on site at the time of a fire or other emergency that involves the fire protection systems.

The inspection, testing and maintenance of water storage tanks may require that the tank and/or other fire protection systems be taken out of service, resulting in an impairment to the fire protection systems. If the water storage tanks(s) are the sole source of fire protection water to your facilities, an alternate water supply should be arranged while the tanks are out of service. Proper impairment handling procedures should be followed during any impairment to the fire protection system.

PHOTO COURTESY OF ROBERT WOODARD. USED WITH PERMISSION.

During an impairment of the water supply to this facility, portable tanks were delivered to the site and connected to the fire pump. Fire protection was maintained in service due to proper impairment handling procedures.

The information and techniques described in this article are provided for illustration and general information and may not be appropriate for your specific equipment. Tank installations vary based on tank type, its age and manufacturer design, so prior to performing testing and maintenance, refer to information and instructions provided by your fire protection contractors, consultants and the manufacturer of your specific systems and equipment.

Systems Included in NFPA 25

NFPA 25 addresses sprinkler, standpipe and hose, fixed water spray and foam water protection systems. It covers the components of these systems, such as private fire service mains and appurtenances, fire pumps and water storage tanks, and valves that control system flow. It does not cover residential installations for one- and two-family dwellings and manufactured homes. This article focuses on Chapter 9, Water Storage Tanks. All items discussed in the previous articles regarding valve inspection and testing, records plans and calculations, impairments to the fire system should be completed. This article discusses items that apply specifically to water storage tanks. NFPA 25 uses NFPA 22, Standard for Water Tanks for Private Fire Protection, as the basis for its inspection, testing and maintenance standards. Not all items listed in NFPA 25 are included in this article, and NFPA should always be referenced for the complete standard.

As a review, a comprehensive program includes the following elements:

•**Inspection.** A visual examination of a system to verify that it appears to be in operating condition and is free of physical damage.

•**Testing.** A physical trying or operation of a system or part of a system to ensure or prove that it is functioning properly, as intended, or to an acceptable standard of operation.

•**Maintenance.** The work performed to repair and/or maintain equipment in operable condition.

Trained in-house staff or a qualified contractor may perform the service. As with any inspection, maintenance and testing program, good recordkeeping is important. Written logs should be maintained, and relevant results should be retained for future reference or AHJ review. Ultimately, it is the property owner's responsibility to ensure that the systems are properly serviced. Tenants may also want to ensure that the work is completed satisfactorily. Management should review completed reports and correct deficiencies. An inspection and testing program is of limited value if identified system deficiencies are never corrected.

Wood stave gravity tank on the roof of a New York City building.

Water Tanks

Fire water storage tanks have been an important feature of industrial fire protection systems over the last 150 years. Elevated gravity tanks were some of the earliest tanks used and were once a common sight at industrial mill buildings throughout the early industrial age in the U.S. Insurance underwriters have considered elevated gravity tanks as one of the most reliable sources of water for fire protection, and facilities with them usually receive favorable rating credits, which correspond to lower insurance premiums.

NFPA adopted the original

PHOTO COURTESY OF FIRECON/CRAIG SCHROLL. USED WITH PERMISSION.

A steel tank installed in the penthouse of a high-rise building as a gravity tank. Concrete tanks may also be used as a gravity tank.

Standard on Gravity Tanks in 1909. That standard has evolved into today's NFPA 22. High-rise buildings have used elevated gravity tanks and roof tanks for several decades because the public water supply pressure was not adequate to provide sufficient pressure to reach the hose stations and sprinkler systems on top floors.

Gravity-fed water supplies do not require a mechanical means to provide pressure to the fire system. The elevation of the tank takes advantage of gravity to supply the pressure. One foot of elevation will provide approximately 0.433 psi, and a column of water 2.31 ft high will produce 1 psi at the base of the column. A gravity tank, which has an elevation of 125 ft will produce a static pressure of approximately 54 psi at the base of the column or pipe, which runs from the tank to the ground.

Another early tank used in mill facilities and high-rise buildings is the pressure tank. The pressure tank is a pressure vessel and is subject to jurisdictional pressure vessel inspections just as boilers and other pressure vessels. Tanks are installed in the building, typically on the top floor, and filled with water to approximately two-thirds capacity. Air pressure is applied to the tank to provide the needed pressure. The pressure must be sufficient to push all of the water out of the tank while maintaining the necessary residual pressure required to supply the sprinkler systems.

The floor of this fire pump room also serves as the top of the below-grade concrete tank. Two vertical turbine fire pumps are extended into the tank to supply protection water for the sprinkler systems. The pump in the foreground is driven by a vertically mounted electric motor. The pump in the background is driven by a horizontal diesel engine with a right angle drive on the top of the pump.

As fire pumps became more common, ground-level suction tanks were installed as a stored water source. Most of these tanks are installed at grade and normally provide positive head on the fire pump so the pump need not draft from the tank. Below-grade tanks usually include a vertical turbine pump, which extends into the tank.

Tank Construction

Tanks may be built of steel, wood, concrete, coated fabrics or even fiberglass-reinforced plastic tanks. Elevated tanks must be supported by steel or reinforced concrete towers. Using these materials, several different methods of construction are used. NFPA 22 provides guidance for the installation methods and arrangement of the tank and associated valve arrangements.

Tank Inspection

Tank inspection will vary slightly depending on the type of tank installed at a facility. NFPA's requirements should be expanded based on recommendations from the tank manufacturer and the fire protection consultant and contractor. Each specific facility situation must be taken into account when setting up an tank inspection, testing and maintenance program.

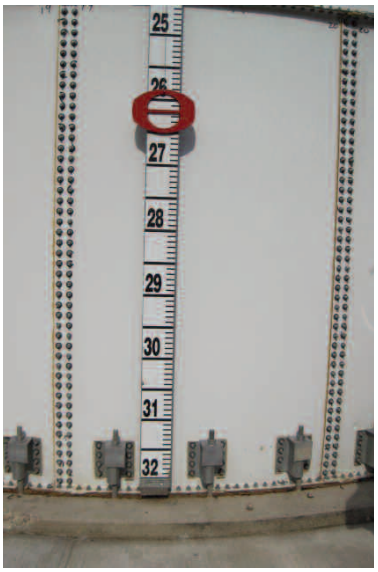

PHOTO COURTESY OF ROBERT CLEMENTI. USED WITH PERMISSION.

This is a ground-level suction tank supplying a fire pump. Note the construction of this tank is steel, which has been bolted together. This tank is located in an earthquake-prone area, and foundation bolts have been installed around the tank base to help hold it in place during an earthquake. The tank water level indicator shows that the tank level is at approximately 26 ft of the 32 ft of tank height.

The inspection is generally divided into external and internal workings of the tank. Conditions on the outside of the tank may also provide clues as to the condition of the tank internally. For instance, if the water is black or brown, this may indicate internal corrosion. Staining on the tank or concrete floors outside of the tank may indicate seepage.

Exterior Tank Inspections

The water level should be inspected on a monthly basis. On most tanks, this is as simple as looking at a sight gauge on the side of the tank. For elevated gravity tanks, there is usually no exterior sight gauge. An electronic indicator may be provided, or the manual fill valve may be opened to fill the tank until water begins to flow from the

The tank water level indicator is not functioning because the cable to the float inside of the tank has become disconnected. The indicator has dropped to the ground. This is a welded steel tank.

overflow pipe. NFPA 25 permits the frequency to be extended to quarterly if the water level alarms are connected to a constantly attended location. From a practical manner, I suggest that the tank water level be inspected weekly in conjunction with other valve or fire pump inspections and tests. It usually takes a glance at a gauge and is not labor-intensive.

Air pressure in a pressure tank should be inspected on a monthly basis. NFPA 25 permits the frequency to be extended to quarterly if the air pressure alarms are connected to a constantly attended location. From a practical standpoint, I suggest that the tank air pressure be inspected weekly in conjunction with other valve inspections. It usually takes a glance at a gauge and is not labor-intensive.

The air pressure on a pressure tank must remain at the appropriate level. Too much pressure could lead to a condition called air lock, which could occur if both a pressure tank and gravity tank are connected to a common water supply feeding sprinkler systems. In the event of a fire with sprinkler activation, when the water from the pressure tank is exhausted, too much remaining air pressure acting against the check valve of the gravity tank may hold it shut, preventing the water from flowing from the gravity tank to the operating sprinkler heads.

Air lock can be prevented by increasing the volume of water in the tank, and decreasing the air pressure. When the tank fully empties, little or no air pressure should remain in the tank.

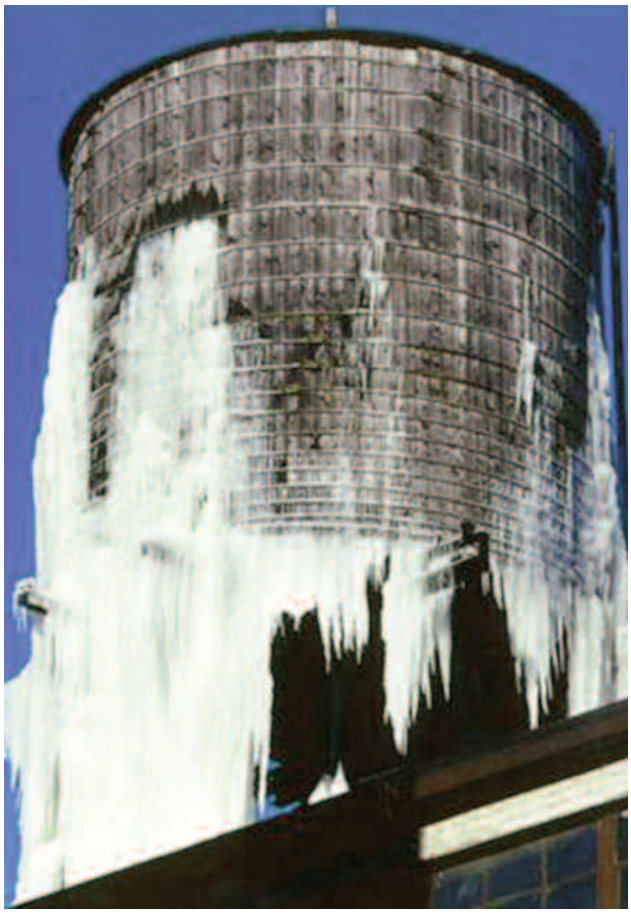

PHOTO COURTESY OF AMERICAN PIPE AND TANK LINING CO., LONG ISLAND CITY, NY. USED WITH PERMISSION.

Failure to maintain adequate heat in a tank during cold weather months may lead to catastrophic failure of the tank.

Tanks installed in climates with freezing potential should be provided with heat. Heating systems should be inspected daily during the heating season. NFPA 25 permits the frequency to be extended to weekly if the low water temperature supervision alarms are connected to a constantly attended location.

Water temperature in tanks goes hand in hand with inspection of the heating systems. Water temperatures should be maintained at not less than 40 °F (4.4 °C). The water temperature should be inspected and recorded weekly during the heating season. NFPA 25 permits the frequency and recording temperatures to be extended to monthly if low water temperature supervision alarms are connected to a constantly attended location.

I recommend to clients that more frequent checks are a worthy pursuit, especially if your facility is in a severe temperature region where temperatures may fall below 0 °F (-18 °C). During my career, I am aware of two tanks that froze. One was a gravity tank, the other a ground-level suction tank. In the case of the gravity tank, the freezing water expanded and split the seams of the tank and the pipe column leading from the tank to the ground. The freezing condition was noted when the ice began to thaw and drip. Due to the extensive damage, the tank was abandoned and a fire pump and ground-level fire pump suction tank was installed at substantial cost. Repairs to the ground-level tank were less costly but still substantial.

On a quarterly basis, the tank exterior, supporting structure, vents, foundation and catwalks or ladders should be inspected for signs of obvious damage or weakening. A good set of binoculars is a worthy investment for tall tanks. The area surrounding the tanks and supporting structure should be inspected at least quarterly to ensure that the area is free of trash, debris, brush or other material which could present a fire hazard or result in accelerated corrosion. The tank and supporting members should be free of snow and ice accumulation or buildup. The weight of the ice is a substantial additional load on the structural members supporting the tank. Coated fabric tanks should be inspected to verify the supporting ground is free of erosion.

Wooden tanks should be inspected annually to verify the condition of the hoops and grillage. I recommend to clients that this task should be contracted to a reputable firm experienced in the construction, inspection, testing and maintenance of wooden tanks. Relatively few companies exist with competencies to maintain these tanks and fewer who build or rebuild them.

The exterior painted, coated or insulated surfaces of the tank and supporting structures should be inspected annually. Many companies that own tall gravity tanks rely on contractors experienced in high tank work to complete this task. Unless you have personnel experienced in this type work and have adequate fall protection equipment and training, this is typically contracted work. Although some sprinkler contractors perform this work, many will

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This is a vortex plate inside of the fire pump suction tank. It prevents a vortex (a swirling funnel, which allows air into the suction pipe and fire pump). The anti-vortex plate is required equipment in a suction tank. This is a welded steel tank. The floor is constructed of steel panels laid on fill material. Setting of the fill material can create voids under this steel floor.

PHOTO COURTESY OF MATRIX RISK CONSULTANTS INC. USED WITH PERMISSION.

Over time, a significant amount of silt and sediment accumulates inside a tank. This material should be removed when internal tank maintenance is performed.

PHOTO COURTESY OF MATRIX RISK CONSULTANTS INC. USED WITH PERMISSION.

Low water level alarm device and low water temperature alarm devices located near the top of a steel suction tank. The ladder leads to the roof access port.

subcontract this work to others. Unfortunately, this inspection is an overlooked task for far too many tanks.

Interior Tank Inspections

Internal inspection should be conducted every 3 years for the interior of steel tanks, which are not provided corrosion protection. All other tanks should be inspected on a 5-year basis. Stencil the date and condition results of the last internal tank paint job in a conspicuous location, such as at eye level near the manway into the tank.

NFPA 25 offers specifics on internal tank inspection, with supporting material in the annex. The tank may be inspected from underwater, or it may be drained for the inspection. If the tank interior is to be inspected from underwater, silt should first be removed from the floor of the tank. The tank and auxiliary systems such as the heating system and components (including piping) and anti-vortex plates (also referred to as "vortex plates") should be inspected.

The tank interior should be inspected for signs of pitting, corrosion, spalling, rot, other forms of deterioration, waste materials and debris, aquatic growth, and local or general failure of interior coating. If any of these conditions exist, additional measures should be taken in accordance with paragraph 9.2.7, which is a drained inspection and testing of the tank.

Tanks with ring-type foundations with sand in the middle should be inspected for evidence of voids beneath the steel flooring. This may be noted by looking for dents or depressions in the tank floor. In addition, walking on the tank floor and looking for floor buckling will also be identifiers. If voids are found, grout or other acceptable fill may be injected below the floor to fill them.

A contractor may perform the following tests in a drained steel tank:

•Evaluate the tank coating with an adhesion test in accordance with ASTM D 3359, Standard Test Methods for Measuring Adhesion by Tape Test. This test is also commonly referred to as the cross-hatch test.

•Take dry film thickness measurements at random locations to determine overall coating thickness.

•Take nondestructive ultrasonic readings to evaluate wall thickness where there is evidence of pitting or corrosion.

•Perform spot wet-sponge test on interior surfaces to detect pinholes, cracks or other compromises in the coating. Special attention is normally given to sharp edges, such as ladder rungs, nuts and bolts.

•Test tank bottoms for metal loss and/or rust on the underside. Ultrasonic testing is performed where there is evidence of pitting or corrosion. If ultrasonic testing is not available, an alternative is the removal, visual inspection and replacement of random floor coupons.

•Vacuum-box test tanks with flat bottoms at the bottom seams, per test procedures in NFPA 22.

Testing

The tank heating equipment should be tested prior to the heating system. If provided, low and high water temperature alarms should be tested monthly during cold weather months. Low and high water level alarms should be tested semiannually.

Pressure gauges should be tested with a calibrated gauge every 5 years. Gauges not accurate to within 3% of the scale of the gauge should be recalibrated or replaced.

Level indicators should be tested every 5 years. They should be accurate and should move freely. If a tank has a mercury gauge, NFPA 25, annex material A.9.3.1, offers the proper method to test the gauge. I find that most mercury-filled equipment at facilities that I

PHOTO COURTESY OF MATRIX RISK CONSULTANTS INC. USED WITH PERMISSION.

The overflow of a tank is typically a funnel attached to a pipe, which extends through the tank wall. This is a welded-steel, ground-level suction tank.

visit has been removed over the years. All automatic tank fill valves should be tested annually in accordance with the manufacturer's instructions. The valve should be activated automatically by lowering the water level in the tank. The refill rate should be measured and recorded.

Maintenance

Tanks should be maintained at the full or appropriate water level. Hatches and covers should be maintained in the closed and latched positions. No debris or waste materials should be allowed to accumulate, and no unwanted or undesirable foreign items should be in the tank. Silt should not be allowed to accumulate in the tank. Any foreign body has the potential of being transported into the underground fire main system or into the sprinkler system piping. Obstructions in sprinkler systems can prevent the sprinklers from operating properly during a fire, and once introduced into the sprinkler piping, are expensive to locate and remove.

Embankment-supported coated fabric (ESCF) suction tanks should also be maintained in accordance with the tank manufacturer's instructions. Exposed surfaces of ESCF tanks should be cleaned and painted every 2 years or in accordance with the manufacturer's instructions.

Automatic tank fill valves should be maintained by a qualified person following the manufacturer's instructions and in accordance with the AHJ. Rubber parts should be replaced in accordance with the manufacturer's instructions. Strainers should be cleaned quarterly.

Table 9.6.1, Summary of Component Replacement Action Requirements, identifies specific instructions for whenever a component in a water storage tank is adjusted, repaired, reconditioned or replaced. These instructions are important to verify that the device is properly installed and operational.

If tanks have lightning protection systems, they should be inspected, tested and maintained in accordance with NFPA780, Standard for the Installation of Lightning Protection Systems.

Conclusion

Fire water storage facilities are a vital portion of your fire protection system. They should be inspected, maintained and tested to ensure that an adequate water supply is available in the event of a fire. Following the procedures outlined in NFPA 25 will help ensure that your equipment will operate properly when you most need it. ✪

References

National Fire Protection Association (NFPA). (2008). Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems [NFPA 25]. Quincy, MA: Author.

NFPA. (2009). Standard for Water Tanks for Private Fire Protection, 2008 Edition [NFPA 22]. Quincy, MA: Author.

Walter S. Beattie, CSP, CFPS, CSHM, *joined the volunteer fire service in 1969 and remains involved in fire suppression and protection. He has worked in the highly protected risk insurance field since 1979 in various capacities, including senior loss control specialist, HPR technical manager, underwriting special agent and account engineer. He is senior consulting engineer, insurance service, with Matrix Risk Consultants Inc. in Miamisburg, OH. He was named 2007-08 Fire Protection Branch (now Practice Specialty) Safety Professional of the Year Award and is currently that group's Assistant Administrator.*

Practice Specialty Officers Elected by Acclamation

The Fire Protection Practice Specialty (FPPS) Nominating Committee nominated Walter S. Beattie, CSP, CFPS, CSHM, as administrator and Gabriel F. Miehl, CSP, CFPS, as assistant administrator.

As required by the Society Operations Guide, the Nominating Committee's decision was submitted to and approved by the current FPPS administrator and the Society Nominating and Elections Committee. No other FPPS member submitted a written petition for nomination by Feb. 15, 2010; therefore, the slate stands as submitted.

In accordance with Society Operations Guide 11.2, since the nominees were unopposed, Walter Beattie and Gabriel Miehl are hereby declared elected by acclamation. Congratulations to these FPPS officers. ✪