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Fire Pumps

Inspection, testing and maintenance of fire pumps are critical to fire safety. Fire pumps help supply hydrants and sprinkler systems with the flow and pressure needed to control a fire. This is the second in a series of articles on the inspection, testing and maintenance of water-based fire protection systems. The first article, "Fire Sprinkler Systems," appeared in January 2009 (Fireline, Vol. 1, No. 1). This article focuses on fire pumps and provides a practical review of what should be included in a typical program. Each program should be customized to meet a site's specific needs.

The primary standard used in most companies and municipalities is NFPA 25, Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems. NFPA 25 establishes the 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 to start to meet a facility's needs.

A program that meets the minimums stated in NFPA 25 is an ongoing program that typically requires weekly interaction with the systems.

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

Photo 1: A typical electric fire pump installation. An electric-driven fire pump with the controller to the rear and the jockey pump to the left.

A program that meets the minimums stated in NFPA 25 is an ongoing program that typically requires weekly 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. Your staff must be familiar with the facility's systems, and they should know what actions to take n 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 information and techniques described in this article are provided for illustration and general information and may not be appropriate for your specific equipment. Fire pump installations vary by age and manufacturer, so before performing testing and maintenance, refer to the 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 8: Fire Pumps. All items discussed in the first article regarding valve inspection and testing, records plans and calculations and impairments to the fire system should be completed. This article discusses items that apply specifically to pumps. NFPA 25 uses NFPA 20, Standard for the Installation of Stationary Pumps for 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 functions properly, as intended, or to an acceptable standard of operation.
- Maintenance. The work performed to repair and/or maintain equipment in operable condition.

Photo 2: A fire pump house and suction tank. Note the fire pump test header and fire department connection.

Photo 3: Two in-line fire pumps installed side by side in a pump room.

Photo 4: The packing glands are located where the shaft enters the pump. The inboard bearing is on the pump housing frame. The flexible coupling is located between the pump and the driver.

The service may be performed by trained in-house staff or by a qualified contractor. 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 systems are properly serviced. Tenants may also want to ensure that 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.

Proper impairment handling procedures must be used whenever any portion of the fire system is taken out of service or otherwise impaired. NFPA 25, Chapter 15 outlines procedures to be followed to properly manage fire system impairments. Also, the article "Handling Impairments to Fire Protection Systems," which appeared in *Professional Safety* (Oct. 2008, pp. 60-63) provides guidance to handling impairments of fire systems.

Fire Pumps

Fire pumps provide waterflow for sprinkler systems, standpipes, hydrants and other fire protection systems. If the existing city water supply is not adequate to provide enough waterflow at pressures needed by the sprinkler systems, a fire pump may be used to boost the pressure. Fire pumps are also installed in conjunction with a tank where no public water supply exists. In this case, the pump and tank may be the sole water supply for the sprinklers and hydrants of your facility. Facilities with critical operations, or high values, may have a fire pump and tank, which is redundant to the existing public water supply.

Fire pumps should be thought of as a group of components that work together to create a complete fire pump assembly. The main components include water supply and discharge piping, the fire pump, a driver to provide power to the fire pump and a controller, which turns the fire pump on and off and monitors its operation. In addition, there are several auxiliary pieces of equipment. These include pump accessories (pump shaft couplings, an automatic air release valve, pressure gauges and relief valves), fire pump test devices, pump relief valves and piping, alarm sensors and indicators, right-angle gear sets (for engine-driven vertical shaft turbine pumps), pressure maintenance (jockey) pump and accessories. Many types of fire pumps and fire pump arrangements are available for installation. This article focuses on electric motor or diesel engine-driven centrifugal pumps.

The Pump

Fire pumps in use today are primarily centrifugal pumps. The pumps may be single or multiple-stage pumps with rated capacities from 250 GPM to 5,000

Photo 5: Two vertical turbine fire pumps taking suction from a reservoir. The pump room floor is the top of the water reservoir. The near unit has an electric motor mounted vertically on the pump. Behind is a diesel driven vertical turbine pump with a right-angle drive.

Photo 6: A diesel-driven horizontal split-case fire pump. The instrument panel is at the top of the engine. The cooling line and bypass are located alongside of the engine. The batteries are located on the opposite side of the engine so the operator does not stand in front of, or reach over them, to operate the pump.

GPM with net pressures up to 400 psi. Pumps may be installed in either the horizontal or vertical position. Horizontal pumps may be horizontal split-case or in-line suction pumps, with horizontal split-case pumps as the most common. Vertical shaft, turbine-type pumps have multiple impellers, which are suspended by a column pipe that houses the impellers, shaft and bearings. This pump is typically used in situations where a suction lift is needed, such as from an underground reservoir, well, river or lake. All major components of the fire pump assembly should be provided with nameplates indicating the equipment ratings.

The Pump Driver

Fire pump drivers are typically diesel engine-driven, electric motor-driven or steam turbine-driven. Gasoline engines and steam-reciprocating drivers are seldom seen today.

Electric Motors

Electric motors have been matched to the pump when designed and should meet NFPA 70, Article 695, as well as other applicable articles. Electric motors for fire pumps normally (but not always) have dedicated electric feeds, which are located before all other plant disconnecting means. This means that if all power is shut off to the facility, the power to the fire pump continues to be energized, and the fire pump will continue to operate, feeding water to the fire protection systems.

Controllers for electric pumps should be located within sight of the motors. Since these units are installed on motors expected to function on an emergency basis, they are provided with fuses rated at a much higher capacity than nonemergency rated motors. They will not shut down on overcurrent power conditions as other normal motors and will continue operating under adverse conditions, even to the point of self-destruction.

NFPA 20 provides specific protection criteria for control circuits. Electric fire pump installations in critical applications may also be provided an alternative backup power source, such as a generator. These power sources are connected to the controller through transfer switches. NFPA 20 is the guiding document of transfer switch arrangement.

Diesel Engines

Diesel engines are also matched to the pump they will power. They are designed and arranged for emergency service and will have features not normally provided on nonemergency equipment. In the event of unusual operating conditions, it may run to destruction to continue providing water to fire protection systems.

Diesel engines have two battery storage units, which, at 40 °F (4.5 °C), have twice the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer. They must be capable of maintaining a 3-minute attempt-to-start cycle, which is six consecutive cycles of 15 seconds of cranking and 15 seconds of rest. The attempt-to-start cycle is important to ensure that adequate reserve battery capacity exists to attempt multiple starts of the unit, if needed.

The cooling system for the driver is typically provided with a heat exchanger, which is fed from the pump's discharge. It normally has a visible discharge so that pump operators can monitor the flow and temperature of the cooling system. A bypass may be provided so that pump room attendants may provide manual cooling flow if the strainer on the automatic line becomes plugged or if a solenoid valve fails to operate.

NFPA 20 provides ventilation specifications for the fire pump room. The diesel engine air intake and exhaust systems must meet these specific specifications to operate efficiently.

Controllers for diesel engines should be located within sight of the motors. The controller will have plainly visible visual indicators that will show the sta-

tus of the unit, as well as any unusual features. It will have an audible alarm that can be heard while the engine is running, and it will provide visual and audible indication upon critically low oil pressure in the lubricating system, high engine jacket cooling temperature, failure of the engine to start automatically and shutdown of the engine from overspeed. There are also indicators for battery failure or missing batteries.

Weekly Inspections & Tests

Qualified and competently trained personnel should conduct weekly checks of the fire pump house, and a written check list should be used. These personnel must be in attendance during the pump's operation. The operator should visually observe that the pump is operating properly. Adjustments should be made as necessary.

Record the system suction and discharge pressure readings. Visually check the pump packing glands for slight water discharge through the packing and adjust if necessary. Check for unusual noise or vibration. Check the packing boxes, bearings or pump casing for overheating. Record the pump starting pressure. Ensure that the heat is adequate to prevent freezing.

The pump house should be maintained at a temperature not less than 40 °F. Ensure that the ventilating louvers open and close freely. Verify that all fire protection valves in the pump room are in the fully open position. The fire pump header control valve should be closed. All piping should be free of leaks, and engine pressures should be within acceptable ranges. Verify that the electrical systems are in the proper operating conditions.

Electric-Driven Pumps

Verify that the controller lights, such as power on, transfer switch and isolating switch indicators, are illuminated. The electric pump should be run for a minimum of 10 minutes. I suggest to clients that they should start the pump on a pressure drop. This may be accomplished by opening the petcock valve on the sensing line just prior to where it enters the controller. A gauge should be located on the sensing line so you may verify the pump start pressure. While the pump is running, periodically verify that the packing glands have a flow of water through them. The pump and bearings should not be become too hot, and there should be no unusual vibration on the motor or the pump.

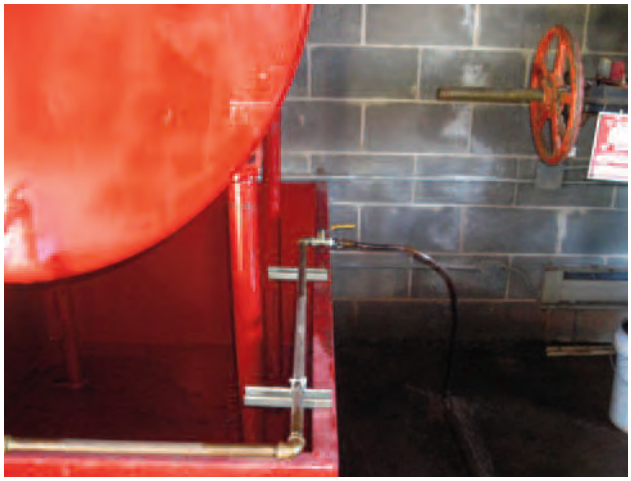

Photo 7: Diesel tanks must be at least 2/3 full. Valves should be within the containment area to help prevent leaks at the threads from spilling into the pump house. The author has seen improperly maintained pump houses with diesel fuel covering the floor to ½-in. in depth.

Diesel Engine-Driven Pumps

Diesel engine-driven pumps must be maintained in top operating condition. Fuel tanks should not leak and should be no less than two thirds full. The controller selector switch should be in the automatic position. The battery voltage and charging current readings should be in the acceptable range. All battery pilot lights should be operable and in the appropriate position. All alarm pilot lights should be off. Oil levels should be verified to be within acceptable range.

Diesel-driven pumps have two types of cooling systems. The most common type is the constant-flow heat exchanger system.

Diesel-driven pumps have two types of cooling systems. The most common type is the constant-flow heat exchanger system. Water from the pump discharge flows through a heat exchanger and provides cooling for the diesel engine. Radiator systems may also be installed and should be maintained with the appropriate coolant levels. Batteries should be checked to verify that the batteries' electrolyte level is within acceptable range and that the terminals are free of corrosion.

Each diesel fire pump assembly should be tested weekly without flowing water and run for a minimum of 30 minutes. As with the electric pump, I suggest to clients that they start the pump on a pressure drop. Each set of batteries should be used to start the diesel. To do this, start the pump in the manual setting on each set of batteries. These starts are in addition to the pressure drop start. While the pump is running, observe the time for the engine to reach running speed. It should operate at full rated output within 20 seconds. Observe the engine instrument panel gauges when the pump is started and periodically while the engine is running. The oil pressure gauge, speed indicator, water temperature and oil temperature indicators should be within proper ranges. If the water discharge of the engine water cooling system is visible, check it for proper flow and temperature. There should be no unusual vibrations or noises from the engine or pump assemblies.

Annual Tests

An annual full flow test of each pump assembly should be conducted. The test verifies that the components perform as well as they did when the pump was

installed. All design information for the pump and driver should be verified and documented prior to the testing. The test results should be compared to the factory specifications as well as to test results from prior years.

Annual fire pump tests are typically performed by flowing water through hose streams connected to the test header. The combined flow measurement from hose streams is used to determine the total pump output. Calibrated gauges are used to determine the suction and discharge pressures of the pump. On electric-driven pumps, voltage and amperage is measured on each of the 3 electrical phases of the motor. The pump speed is read using a tachometer or speed counter, and this reading is compared with the tachometer mounted on the driver, if provided. In high-rise buildings, additional hose flows at the roof may also be required. The jockey pump start and stop pressures should also be verified.

Some fire pump installations are provided with flow meters to measure discharge flows from the fire pump.

Some fire pump installations are provided with flow meters to measure discharge flows from the fire pump. They may discharge to a drain or suction reservoir, or they may be routed to the suction side of the pump in a closed-loop fashion. Where closed-loop flow meters are used, a regular flow test should be performed at least every 3 years for comparison.

Flow meters should be adjusted immediately prior to conducting the test in accordance with the manufacturer's instructions. This is critical to obtain accurate test information. In the event results from flow meters are not consistent with previous annual tests, a flow test using hose streams should be performed. If no provisions exist to perform hose stream discharge tests, NFPA 20 permits verification of results by calibration of the flow meter.

The annual pump test should meet the three operating points of the rated pump curve and should be a minimum of 30 minutes in duration. The three operating points are:

•the churn, where no water is flowing;

•the 100% point, noted on the manufacturer's data plate attached to the pump;

•the 150% point, which refers to 150% of the rated flow at the pressure noted on the manufacturer's data plate.

Each flow should record the simultaneous readings of the suction and discharge pressures and the pump speed. On electric-driven pumps, voltage and amperage measurements on each electrical phase should also be recorded. While simultaneous readings are not always possible, they should be taken at approximately the same time.

Where pressure-relief valves are installed on the system, they should be monitored for their flow and operation. Pressure-relief valves should be closed during flow conditions if it is necessary to achieve the minimum rated pump characteristics. After testing, the relief valve should be reset to its normal position. I suggest to clients that the relief valve should also be exercised to prevent it from becoming corroded or otherwise inoperable.

For pump installations provided with an automatic transfer switch, testing should ensure that overcurrent protection devices do not open. A power failure condition should be simulated while the pump operates at peak load. The transfer switch should transfer power to the alternate power source immediately without tripping any fuses or circuit breakers. It should be verified that the fire pump continues to perform at peak load. After that, the power failure condition should be removed, and verification should be made that, after a time delay, the pump is reconnected to the normal power source.

Alarm conditions should be simulated by activating alarm circuits at the alarm sensor locations, and all such local or remote alarm indicating devices (visual and audible) should be observed for operation. This may be accomplished by using a jumper wire to connect the wire nodes of the high water temperature supervision device or the connections on the low oil pressure supervision device.

The failure-to-start sequence test on diesel-driven fire pumps should be performed to verify that the controller

Photo 8: (right) Test header with hoses connected.

Photo 9: (far right) Flow is measured using a pitot tube and calibrated gauge.

will stop trying to start the engine upon a failure to start. The controller should provide a crank cycle of 3 15-second start attempts per battery with 15-second rest periods in between the starting attempts. After this sequence, the controller should stop trying to start the pump. The fire pump control panel should provide an audible and visual alarm signal. This feature intends to conserve enough battery power so that there is enough reserve power in the batteries for the fire pump operator to correct a problem and to start the pump manually. To perform this test, many units will require that the cable from the cranking solenoids be disconnected at the starter terminal. Your specific unit's manufacturer should be consulted to verify the proper technique.

Only competently trained personnel should test the overspeed shutdown of diesel-driven fire pumps. I recommend to my clients that the diesel engine should not be put into overspeed to test this device. Some newer diesel engines have an electronic test feature for this device. Older engines may be tested by inserting a speed-increasing gear box into the sensing line. This gearbox will allow the pump to sense an rpm at higher than the actual engine speed and shutdown in a safe manner. An overspeed shutdown requires a manual reset before it is able to be restarted. Newer engines have a toggle switch to reset the engine to permit restarting. However, older engines may require manual reset.

Maintenance

NFPA 25 notes that a preventive maintenance program should be established on all pump assembly components in accordance with the manufacturer's recommendations. Whenever a component in a fire pump is adjusted, repaired, rebuilt or replaced, the tests required to restore the system to service should be performed in accordance with NFPA 25, Table 8.6.1. These are important aspects of the overall maintenance of your equipment.

Generally, most maintenance operations for fire pumps are conducted on a quarterly or annual basis. Normal engine and fuel system checks should be weekly, with repairs performed immediately. Some of these checks include verifying engine oil levels, condition of rubber hoses and belts, water jacket heater condition and exhaust system leaks and general inspection of the electrical system. After the waterflow portions of the annual fire pump test or fire protection system activations, the suction screens should be inspected and cleared of any debris or obstructions.

Quarterly Maintenance

Several items should be attended to on a quarterly basis. The diesel fuel system strainer, filter or dirt leg should be cleaned. Engine parts, such as the crank case reader, should be checked and cleaned as needed. The cooling system strainer should be cleaned. Battery terminals should be cleaned and tightened.

Photo 10: Technician taking voltage readings during a fire pump test. The emergency run knob is at the lower right of the control panel. Pushing this knob and locking it in place will engage the contactor to start the motor.

Annual Maintenance

On an annual basis, fire pumps should have a general overall maintenance program. Lubricating oils for diesel engines should be replaced after 50 hours of operation or annually, whichever comes first. Lubrication of the pump bearings, mechanical transmission couplings, right-angle gear drives and other moving mechanical parts needing lubrication should be completed.

Electrical connections should be inspected and tightened as needed. The fire pump coupling alignment should be checked. Also, parallel and angular alignment of the pump and driver should be checked during the annual test. Any misalignment shall be corrected. Diesel engine fuel tanks should be cleaned of any water and foreign material in the tank. All ductwork should be inspected and cleaned annually. All maintenance normally associated with the diesel engine, electric motor or steam turbine should also be performed annually.

Other Tests

Other equipment on which the fire pump relies should also be tested. Engine generator sets supplying emergency or standby power to fire pump assemblies should be tested routinely in accordance with NFPA 110, Standard for Emergency and Standby Power Systems. Automatic transfer switches should also be tested routinely and exercised in accordance with NFPA 110. Tests of appropriate environmental pump room space conditions (e.g., heating, ventilation, illumination) should be made to ensure proper manual or automatic operation of the associated equipment.

Other Considerations

After all inspections, tests and maintenance item testing are completed on the fire pump installation, qualified individuals should perform a thorough review and interpretation of the results. Deficiencies should be corrected as soon as possible. NFPA 25, Annex C (Possible Causes of Pump Troubles) contains a partial guide to locating pump problems and their possible causes. It also suggests some possible remedies.

Emergency Starting of Fire Pumps

Members of the plant emergency organization and local fire department should review the system on a regular basis and at least annually. They should be familiar with the method to manually start the fire pump in the event that the controller is out of service. A member of the emergency response team should respond to the fire pump room whenever a fire alarm sounds. This person should remain there to oversee the operations of the pump throughout the entire event. Preplanning should specify the person's actions and whether it is safe to remain at the pump through a fire.

Electric Fire Pump

Electric pump control panels usually have emergency starting instructions posted on the front of the panel. Some controllers will have a plunger knob in the lower right corner of the controller. The knob is pushed in to operate an internal arm, which pushes the contactors to engage the electrical circuit. Then turn the knob to lock it in the closed position. Other units may use a lever, which physically closes the circuit.

After the engine has started, check that the engine is operating at its rated speed.

Diesel Fire Pump

Should a diesel-driven fire pump fail to start, you may start it manually by using controls in the valves on the engine. This procedure will vary depending on manufacturer, model and equipment age. Again, it is crucial that operators know this procedure and are familiar with the operations of the specific pieces of equipment in your facility.

1) Open both manual bypass valves in the cooling water supply line.

2) The instrument panel on the diesel engine may have a toggle switch to select automatic or manual mode.

3) Depending on the manufacturer, the toggle switch should be placed in the manual operation position.

4) Check the battery voltage gauges and select the battery with the highest voltage to start the pump.

5) Operate the appropriate battery contactor lever, either Battery A or Battery B, to start the engine. If the crank solenoid lever does not engage the starter, repeat using the crank solenoid of the alternate battery.

6) Release the contactor lever immediately after the engine starts.

7) Note the pressure gauge on the engine coolant line. Bring the pressure in the coolant line down to a pressure appropriate for you specific unit by adjusting one of the coolant line bypass valves. You will have noted this pressure during your weekly test operation.

8) If the engine does not start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking may indicate that the engine is not receiving fuel. To prevent damage to the starter in engines using electric-starting motors, do not engage the starter motor for more than 15 seconds. Wait 15 seconds between each attempt to start.

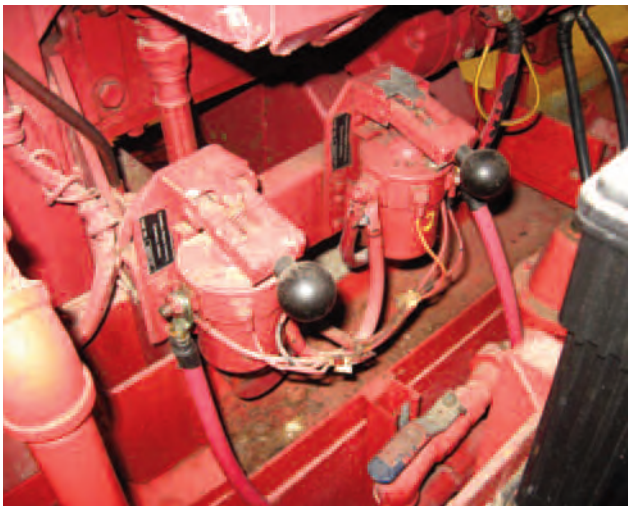

Photo 11: Battery contactor levers located on the side of a diesel engine.

9) Verify that engine oil pressure is indicated on the gauge within 15 seconds after starting.

10) After the engine has started, check that the engine is operating at its rated speed. Verify engine water temperatures and oil pressures. Verify that you have appropriate suction and discharge pressures on the pump and monitor the pump operation.

Conclusion

Fire pumps are a vital portion of your fire protection system. Like any piece of equipment, they require regular inspection, testing and maintenance to ensure that they remain in top operational condition. Following the procedures outlined in NFPA 25 will help ensure that your equipment will operate properly when you most need it. ✪

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