INSTALLATION OF STATIONARY PUMPS FOR FIRE PROTECTION

INTRODUCTION

National Fire Protection Association (NFPA) documents describe a level of fire protection agreed on by persons representing a variety of interests. The guidance in these documents does not reflect unique conditions or special considerations, such as system performance under adverse conditions. Nor does NFPA guidance reflect the increased system reliability that AXA XL Risk Consulting recommends for high valued properties.

This PRC Guideline states the position on selected provisions of NFPA 20 that AXA XL Risk Consulting believes require clarification or changes. To understand the position, this PRC Guideline must be read with a copy of NFPA 20. The provisions of the NFPA document are not repeated.

POSITION

General

The requirements for testing and maintaining fire pumps are found in Chapter 8 of NFPA 25. Additional guidance is found in PRC.12.0.2, PRC.14.2.1.1 and PRC.14.2.1.3.

The definition of a packaged fire pump assembly was introduced as a means of clarifying what is included in a fire pump package. These pre-packaged units can arrive with the controller mounted onto the same frame as the fire pump and driver. The controllers are so sophisticated today, the vibration from the driver can create issues so it is recommended to move the controller to a near-by location.

Can pumps are not recommended and should only be accepted with the concurrence of the AXA XL Risk Consulting’s Risk Consultant. The life cycle of these pumps typically are not as long as horizontal centrifugal pumps. These are typically used when there are space limitations.

Plans

Submit complete plans of the proposed installation to the appropriate AXA XL Risk Consulting Plan Review Office for review and acceptance prior to the start of any work, unless directed otherwise by the Risk Consultant. The installation should meet the latest edition of NFPA 20. Submit sufficient copies of the installation plans so that, after returning a sufficient number of copies, one may be retained for use by the AXA XL Risk Consulting‘s field representative and one as a file copy. Provide the following information for review:

- The appropriate manufacturers' literature, including details on the pump, driver, coupling, controller, piping and valving, and accessories.
- A Bill of Materials showing make, model and part numbers of all components clearly indicating which equipment options will be provided so that listings can be confirmed.
- Complete drawings showing plan and section views of the pump arrangement. Include the pump, piping, valving, jockey pump, drivers, sensing lines and controllers.
- Complete drawings showing internal wiring schematic of the controller and any external wiring.
- Certified fire pump test curve.
- For electrically operated pumps, provide an electrical one-line drawing from the utility connection to the pump motor controller to confirm that no devices or shared loads exist and that no undue exposure exists to vital feed cables. Indicate ratings and settings of breakers, fuses, switches and transformers. Include sufficient details on the electric motors to validate their adequacy for fire pump service. Also show size and length of all circuit conductors. NFPA 70, Article 695 details this.
- For diesel-operated pumps, provide details of fuel storage, capacity and fuel supply piping arrangement, battery ratings, battery charging system and emergency starting provisions.
- For steam-operated pumps, provide steam turbine details, data on steam supply, steam availability and source. Describe the steam turbine arrangement. If a reducing station is used provide details on the regulation of steam pressure to the turbine and describe the steam by-pass.
- Details on fire pump suction supply.
- Details on pump house (room) including size, construction, cutoffs, protection from fire and other outside influences (flood, windstorm, etc), heat, drainage and ventilation.

Pump Operations

Training should be given to the individual(s) who are responsible for responding to the fire pump room in the event that it operates. They should be trained to a level to know what to do when something goes wrong.

Even today, fire pumps are being installed by those who have very little training or experience with fire protection electrical systems and the unique characteristics of fire protection system design and installation. In order to have an effective fire protection system, utilize only qualified individuals.

This applies as well to the inspection, testing and maintenance of fire protection systems.

Fire Pump Unit Performance

Consider the fire pump, driver and controller as a single entity. An agent of the pump manufacturer should assemble and test the complete unit, and prepare and include a certified curve as part of the review package.

The submitter is responsible for the coordinating all parties involved with the installation and field testing of the fire pump system, including representatives of the equipment manufacturers, AHJ and the facility management.

Liquid Supplies

Evaluate the adequacy of water supplies before recommending or reviewing fire pump equipment. Review the reliability of municipal water supplies, capacity and reliability of stored water sources, seasonal changes in ponds and rivers, reliability of well water sources, quality of the water and potential future water usage.

The test used should be current and no older than 12 months, especially if the pump is taking suction from a municipal supply.

Water Supply

Municipal

A fire pump taking suction from a pressurized water source (city water main), must be able to meet the water demand without compromising its available water supply, otherwise use a fire pump with a sufficient water source. Water supplies that deliver 200% of the rated pump capacity at 20 psi (1.4 bar), at the suction flange of the pump should easily meet the pump's requirement even with future degradation of the suction supply. Select the pump pressure rating based upon available suction pressure and the anticipated system demand. Include the effects of extreme elevation changes. Avoid pressures that exceed the pipe working pressure or that require pressure relief. Pressure relief devices do not react quickly enough to prevent spike damage to the piping system. Where overpressure is a concern, use pumps with flatter pressure characteristics and avoid pumps where churn pressure exceeds 120% of rated pressure. Variable speed control should be considered as well.

Provide a bypass around the pump, equipped with properly valving and a check valve, for emergency use in the event that the booster pump fails to operate. The valves on the emergency by-pass should remain in the open position at all times.

Some local regulatory agencies require low-pressure cut-off devices on booster pumps when the suction pressure is capable of dropping too low. If minimum suction pressure must be maintained, the use of an automatic pilot-operated throttling valve at the pump discharge is preferred. Variable speed controls can accomplish this as well. Design fire pump water supplies so there is sufficient water available for maximum continuous pump operation for the probable duration of the fire. Include hose stream demands when determining fire pump suction tank sizing and automatic fill flow rates.

Stored Supply

Size suction tanks to hold enough water to meet the fire protection water demand for its expected duration. (See PRC.14.0.1.) Where possible, use an automatic fill device to replenish the suction supply during emergency use or testing. Whether automatic or manual, the fill rate must be great enough to fill the entire tank within an 8-h period.

Although properly sized tanks are preferred, when very large suction tanks are needed, automatic fill devices are sometimes used to supply part of that need. The weakness in this arrangement is the possible failure of the automatic fill device or the depletion of proposed filling source during a fire. Therefore, a reliable and adequate suction tank-filling source must be used.

When an automatic fill device is used to meet part of the required fire pump suction supply, size the tank to hold a **minimum of ⅔** of the total required volume. In addition, the automatic fill must maintain a minimum of 25% in the suction tank after the pump has operated at 120% capacity for the expected duration. The fill rate is a function of discharge rate and is not time dependent. The rate of refill must be at least 50% of the pump's maximum flow rate (60% of pump rating). This is usually equal to or greater than the 8-h minimum fill rate.
The water storage should account for not only fixed system demand but manual fire suppression as well.

Even though NFPA 20 allows up to -3 psig (-0.2 barg) at the suction flange when the supply is from a suction tank with its base at or above the pump elevation, a suction pressure at the pump suction flange that never drops below 0 psig (0 barg) is preferred.

Pumps Drivers And Controllers

Fire pumps should be dedicated for fire protection purposes only. Although dual drivers are not allowed by the standard (except for positive displacement pumps) they are considered acceptable until a change needs to be made in regards to the pump and driver. At that time, the current standard should be met.

The fire pump driver should be selected carefully based on needs, infrastructure and long term sustainability.

Maximum Pressure For Centrifugal Pumps

This section reaffirms AXA XL Risk Consulting's position that the pressure developed by the pump should not exceed the system pipe pressure rating. Do not use relief valves or pressure regulating devices to correct a poor design. Variable speed control should be considered if an over pressurization situation exists.

Centrifugal Fire Pump Capacities

If the fire protection system water demand exceeds 120% rated capacity of a proposed pump, provide a larger capacity pump or multiple pumps that meet or exceed the demand. When water demands exceed 2000 gpm (7600 L/min), consider multiple pumps for added reliability. If multiple pumps are used to meet water supply demands, sequential starting should be considered. With one pump out of service, the other(s) can deliver partial protection.

The following tables show some typical pump ratings and their metric nominal equivalents:

Flow rating:

500 gpm	1900 L/min	115 m^3/h
1000 gpm	3800 L/min	230 m^3/h
1250 gpm	4700 L/min	285 m^3/h
1500 gpm	5700 L/min	340 m^3/h
2000 gpm	7600 L/min	455 m^3/h
2500 gpm	9500 L/min	570 m^3/h

Pressure rating:

100 psi	7 bar	7 kg/cm^2	700 kPa
125 psi	8.6 bar	8.6 kg/cm^2	860 kPa
150 psi	10 bar	10 kg/cm^2	1000 kPa

When multiple pumps are used, drive at least one pump by a completely independent non-electrical means such as a diesel engine. (For guidance on water supplies see PRC.14.0.1, PRC.14.0.1.1, PRC.14.1.1.0 and PRC.14.1.1.1.)

Pumps under 500 gpm (1900 L/min) capacity are generally not appropriate. They should only be accepted after concurrence of the AXA XL Risk Consulting's Risk Consultant. Pump installations must feed the entire property; total fire protection water demands are usually in excess of 500 gpm (1900 L/min). The only exceptions may be:

- Where positive displacement pumps are used with foam or water mist systems.
- Where local building ordinances require pumps for only sprinkler protection in a high-rise building.
- Where the pump is used for hose connections only;
- Where the pump is used to maintain static pressure only (jockey pump).
- Or limited service situations.

Pressure Gauges

Annually calibrate pressure gauges used for fire pump testing. Adjust test readings in accordance with the current calibration. Confirm the accuracy of the gauges installed on the pump with a calibrated gauge. Most suction gauges are of the compound type and can easily be checked for accuracy using positive pressure. With open suction conditions taking suction under a lift, e.g., ponds or rivers, measure and compare the actual static lift (distance from water level to centerline of pump) to the vacuum reading on the gauge when the pump operates under shut-off conditions. If the results differ, adjust the gauge or apply a correction factor to the results. When encountering water supplies that may have debris in them, be sure and flush the connections prior to using calibrated gages.

Circulation Relief Valves

Pipe the discharge of the circulation relief valve to a drain at a point where the operator can see the flow. If piped to a floor drain, the drain should be sized large enough to accommodate such a flow. Circulation relief valves have been known to deteriorate with age. Install them in the vertical position as they fail faster in the horizontal position. A properly functioning circulation relief valve is essential to maintaining electric motor driven pump cooling.

Equipment Protection

Generally arrange equipment as follows:

- Locate the fire pump, driver and controller in a cut-off room of at least 2-h rated construction.
- Do not locate new fire pump installations below grade, to prevent damage from flooding or accidental leakage.
- Do not install fire pumps in hazardous atmospheres. Positive ventilated rooms are sometimes used.
- Consider the potential for impact damage from structures like walls where collapse is possible.
- Do not use the pump room for storage.
- Provide sprinkler protection whenever the pump house contains combustible materials such as diesel fuel.
- Locate pump controllers such that water from accidental leaks during testing will not enter the controller when the controller doors are in the open position.
- Separate multiple pumps from each other with noncombustible removable barriers to preclude fire spread from one unit to the other.

For freestanding pump houses:

- Construct pump house with noncombustible materials, including the roof.
- The location of the pump house should minimize the exposures to the pump, especially from other buildings, to prevent a fire or explosion from disabling the fire pump.
- Locate the pump house away from areas, 50 ft (15.3 m) or greater, which can potentially affect it, such as floods, vehicular traffic, main line railroads etc.
- Make sure that the responding fire department can access the fire pump in a safe manner during an emergency.

Emergency Lighting

All pump houses should be afforded emergency lighting normally found in occupied areas and should provide light for 2 hours.

Ventilation

Ventilation is needed to prevent the accumulation of moisture and to maintain suitable temperatures in the pump room. (See PRC.14.2.2.2.)

Valves, Piping And Fittings

For guidance on fire protection mains, refer to NFPA 13 and PRC.12.1.1.0, and to NFPA 24 and PRC.14.5.0.1.

Do not use motorized valves in fire protection piping. If a butterfly valve is used within 50 ft (15.3 m) of the pump suction flange, pump performance can be affected.

A spool-piece at least the length of 10 pipe diameters must be installed between the horizontal elbow and the pump flange for the pump to operate without improperly loading the impeller, cavitating or surging the pump. Proper pump equipment layout will avoid this problem. A vertical elbow, connected at the pump flange, can be used on fire pump arrangements taking suction from a pressurized water source, if a long radius elbow is used. There are diagrams of this in the annex of NFPA 20.

Avoid devices in the suction line that cause excessive turbulence, such as butterfly valves or backflow preventers, due to possible pump cavitation. If they are installed, be sure that they are as far away as possible from the suction flange of the fire pump.

When multiple pumps use a common suction, install isolation valves arranged to optimize suction water reliability. Also install isolation valves between cross-connected water supplies.

Use only listed backflow preventers. Where acceptable to the local authorities, install them on the discharge side of the pump. Consider the friction loss through the backflow preventer during pump selection and pipe sizing.

Fire protection systems are generally designed to operate below 175 psi (12 bar). Many of the sprinkler system components are not listed for pressures above 175 psi (12 bar). However, when pressures above 175 psi (12 bar) can be developed, special heavy duty piping valves and fittings are required. When choosing a pipe rating, also consider the effects of shut-off pressures and trapped surge pressure.

Suction Installation

For horizontal and in-line pumps, maintain suction pressure greater than 0 psig (0 bar) on the pump; no static lift is allowed on new installations. This has been in the standard now for a few years due to high failure rates of foot valves.

Vortex Plate

A square vortex plate measuring at least twice the diameter of the suction pipe is required for horizontal fire pump installations where the suction supply level can be lowered enough to cause a vortex to form. This applies to suction tanks and to supplies using suction cribs in which the water supply level is not self-replenishing. To reduce turbulence, pipe the return flow from automatic fill lines, main relief valves, or meters over the top of the tank, below the lowest expected water level. Locate these lines at least one quadrant away from the suction inlet. For open-suction cribs with a continuous supply where the water level cannot be dangerously lowered, a suction bell located on the pump suction line inlet is acceptable in lieu of a vortex plate.

Relief Valves For Centrifugal Pumps

A relief valve is required only when the pump discharge pressure of a fire pump could exceed the working pressure of the underground or the piping system components. Also, when a variable speed control device is used in case the variable speed control fails.

The overpressure situation usually occurs when the discharge pressure of the pump at shutoff exceeds 175 psi (12.1 bar). Diesel engine driven fire pumps can experience an overspeed condition, although it’s a rare occasion and they are equipped with overspeed protection. The maximum pressure the pump system can provide is at shutoff. If you need to install a main relief valve, it should trickle a small amount of water at shutoff, to ensure that it is working, main relief valves are adjustable as well.

A 125 psi (8.6 bar) rated pump with a 120% shutoff pressure and a 5 psi (0.35 bar) suction pressure (typical suction tank) will probably develop pressure churn of 155 psi (10.7 bar). A 100 psi (7 bar) rated pump with a 140% shutoff pressure and a 5 psi (0.35 bar) suction pressure could develop churn pressure of 145 psi (10 bar). Fire pumps taking suction from a city water main or other pressurized sources, have much higher suction pressures and must be evaluated with care. Variable speed controls should be evaluated for their potential use.

Evaluate potential churn pressures of all pumps before specifying the rated pressure of the pump. Do not design a system that will require a relief valve to avoid excessive pressures. If high pump discharge pressure cannot be avoided, then use system piping with correct pressure ratings.

Use only listed relief valves and pipe them to an open waste cone visible to the pump operator. Where water supplies are limited in volume, wastewater may be discharged to an atmospheric water source through a closed cone equipped with an acceptable high rate water flow device in the return pipe.

The relief valve is supposed to open above the shutoff pressure of the pump to relieve pressure before it damages the piping system. Design the relief valve installation to compensate for any backpressure. Design the water flow devices to activate an audible and visual warning signal at the pump room, as well as at a point of constant attendance. A 1-in. (25-mm) bypass line may be necessary for testing the water flow device.

Pilot-operated relief valves are preferred because they are more reliable than spring-operated valves. However, the use of pilot operated relief valves with vertical shaft turbine pumps has created some problems, especially where the pumps supply deluge systems. It is extremely important that all the air is removed from the main valve chamber, otherwise, the relief valve will open during high instantaneous demands and dump water to waste. (Refer to PRC.14.2.2.1.)

Consider the expected backpressure during relief valve selection. Size valves and discharge piping to accommodate expected flow rates.

Water Flow Test Devices

To properly test the pump at rated conditions, a flow meter cannot return the discharge to the suction pipe. Doing so would only test the water capacity and not the work being done by the pump. (Refer to PRC.14.2.1.1.)

The flow meter manufacturer should determine the specifications for each individual installation. Even though flow testing of the pump may be done with a flow meter, include a fire hose header to periodically (every three years) check the meter's calibration. Actual flow from fire hose nozzles will determine the accuracy of the flow meter, both for acceptance testing and for recalibration. The hose header may also serve as an additional hydrant for fire fighting and water testing purposes. Hydrants could also be used in this regard as well.

Where meters are installed, each pump should have an individual flow meter. When designing a system capable of testing suction capacity by running more than one pump simultaneously, size the hose header accordingly.

When water from a flow meter cannot be discharged into the yard or site drains, it may be returned to the suction tank using an over-the-top feed that discharges below the lowest expected water level to reduce turbulence in the pump suction line.

Install the return pipe so that the water is not subject to freezing. Install the flow meter return independently of an automatic fill pipe unless the automatic fill can be shut off during tests. If the tank has a manual fill, the flow meter return pipe may be common with the fill pipe.

Fire pump test headers should be located outside of the pump room. Preferably using threaded pipe as there have been some instances where the Victaulic fitting has failed and the piping/header became disconnected during a test.

Shop Tests

The pump manufacturer must conduct a shop test at the pump manufacturer's plant using all the devices specified for the final installation. The pump manufacturer should prepare a certified curve for the pump and transmit a copy of the curve for review prior to acceptance tests being conducted.

Pressure Maintenance (Jockey Or Make-Up) Pumps

Jockey pumps maintain a uniform pressure on the system and thus:

- Assure high pressure for the first sprinklers that fuse, increasing their effectiveness, and possibly reducing the number of operating sprinklers.
- Permit automatic fire pumps to start at a higher pressure, resulting in less delay in starting and less chance of a pressure surge.

- Avoid frequent and unnecessary starting of the fire pump due to minor fluctuations in system pressure.
- Increase the reliability of water flow alarms by avoiding the false alarms caused by surges.

Size the jockey pump so it does not cycle too frequently and that it will maintain the desired system pressure. Excessive leakage may warrant repairs to the underground before a fire pump is installed. Avoid using positive displacement pumps for pressure maintenance. The following guidance is given for centrifugal type jockey pumps:

- Use high-pressure piping if shut-off pressure exceeds the working pressure if the piping system.
- Arrange the fire pump to start at a pressure close to its maximum discharge pressure (churn) to limit starting surges.
- Arrange the fire pump to start about 10 psi (0.7 bar) below the jockey pump start pressure to prevent unnecessary false starts of the pump.
- Maintain a minimum 15 psi (0.7 bar) pressure differential between the “start” and “stop” settings of the jockey pump to prevent excessive pump cycling and premature failure of the jockey pump motor controller. There is an example of this in the annex on how to properly arrange the starting pressures of jockey pumps and fire pumps.
- Special attention should be given to the pump to ensure that it is of the proper size.
- The sensing lines for jockey pumps, as pointed out in 4.30 should be installed accordingly and independently of the main fire pump sensing line.

Fire Pumps High-Rise Buildings

Although it is not spelled out in NFPA 20, all pumps should be on the same elevation. It is felt that the supply conductors could be exposed in a fire situation and if the lower pumping unit failed, the remainder of the system would as well.

Centrifugal Pumps

Split case pumps are preferred. NFPA 20 has removed sizing restrictions for end-suction and vertical in-line pumps. Although the current listings of in-line pumps are limited to 750 gpm (2800 L/min), the pumps must be a minimum of 500 gpm (1900 L/min). End-suction and in-line pumps are generally impractical because of their size. Single-stage close-coupled vertical in-line pumps are limited due to the stress created by the weight of the unit.

Select pumps with low churn pressures, when practical even though the pump standard allows the shut-off head to be up to 140% rated head. Do not permit maximum system pressure to exceed the working pressure of the piping.

Factory And Field Performance

See the procedures for fire pump acceptance tests in PRC.14.2.1.1. The information in this section establishes the base line for pump design and performance.

Pipeline Strainer

This device is used to capture small items of debris which can enter the fire pump impeller. Proper flushing of suction lines and proper maintenance of trash bars and screens should eliminate most debris problems.

Water quality of potable and non-potable water supplies is important and can be compromised in many ways. Animal and vegetable matter presents a very serious problem that requires the assistance of a water quality specialist.

Algae breed in stagnant water when exposed to sunlight and can clog suction screens. Chemical treatment with copper sulfate or swimming pool additives can help alleviate this problem, but dead algae may need to be mechanically removed. Some facilities have tried stocking reservoirs with algae-eating fish only to find that the fish create a problem of their own.

Hydrilla weed has made its way to the U.S. and has wreaked havoc in many southern waterways. The hydrilla grows from tuber buds that sprout in the spring to long feathery tentacles that have choked water intakes. Flood waters and pleasure boats are generally responsible for the weed's spread. In some cases lowering the water level and using herbicides has controlled the weeds. Genetically sterile Chinese grass carp have been found to be an effective control measure. It takes about 20 carp per acre (1 per 200 m^2) to control the infestation at a cost of about $8 per fish.

Another serious problem experienced with fire pump suction supplies has been the presence of **Asiatic clams** (Corbicula species, a non-native, freshwater, bivalve mollusk). These clams are very fast growing and can be as dense as 5000 clams/ft^2 (53,800 clams/m^2). In the past 30 years they have spread over 70% of the USA. Back-flushing the piping with chemicals on a periodic basis can control them.

In 1987, fresh-water mollusks called **Zebra Mussels** (Dreissena Polymorpha) were found in the Great Lakes and surrounding rivers. Oceangoing vessels possibly transported them from Europe. They have no food value to humans and have few natural enemies. Waterfowl are known to spread the mollusks during feeding. The chemicals used to control the Asiatic clams are effective on these mollusks but would also be dangerous to fish and other wildlife when used in natural water sources. Zebra mussels found in suction piping cause overheating of operating equipment as well as major reductions in pump capacity. In dedicated fire protection reservoirs, a concentration of 0.5 ppm of chlorine has been found to effectively kill the mollusk larvae, which are distributed by water movement. Suction screens for vertical turbine pumps can be treated such that they repel zebra mussels or special filtering screens can be used as well.

Foundation And Setting

Once the pump is aligned, grout the pump base with an acceptable oil and water-resistant grout to prevent settling and misalignment during operation. The top of the grout may need an epoxy paint applied to it to prevent oil and grease intrusion.

Connection To Driver And Alignment

This section pertains to horizontal split-case pumps and requires listed flexible couplings or shafts. Currently there are no listed flexible couplings for diesel engine driven pumps, however UL is in the process of developing a test standard under UL Subject 448A.There are listed couplings for electric motor driven pumps.

The coupling allows the driver to turn the pump. Many failures of couplings made predominantly of elastomeric materials have been reported. This occurs when there is misalignment or when the set screws for the housings holding the elastomeric insert have loosened, causing the elastomeric insert to drift and deteriorate. Many of the failures occurred during pump starting. Some engine manufactures are using drive shafts to transfer power from the engine to the pump, these are typically offset per the engine manufactures recommendations.

Do not use couplings made predominantly of elastomeric materials on new installations. Until listed couplings are available, flexible couplings must be:

- Strong enough to transmit the specified power from the driver to the pump;
- Constructed in such a manner that the hub or cover component(s) on the drive side is mechanically attached to the hub or cover component(s) on the pump side using a bolt-through mechanism;
- In the process of being listed. The manufacturer must agree to make any changes necessary to bring the installation up to the listed standard.

Replace existing elastomeric couplings as soon as possible. Until they are replaced:

- Verify alignment of pump and driver;

- Inspect the coupling housings during weekly fire pump testing;
- Inspect setscrews for tightness. Thread adhesives may be effective for preventing setscrews from loosening.
- Maintain a spare elastomeric unit for immediate replacement in an emergency.

Water Level Detection

It is vital to know the depth of water in the well. Lack of water could result in serious damage to the pump and to the driver as well. This is discussed in NFPA 25 as well.

Gear Drives

Non-reversing ratchets are required on both diesel and electrically driven vertical-shaft pumps to prevent damage to the pump and prime mover when large volumes of water drain down the suction line, causing the pump and driver to rotate backwards.

Positive Displacement Pumps

These pumps are not intended to be used as primary fire pumps.

The characteristic performance curves for positive displacement pumps are quite different from those of a centrifugal pump. Each pump has a series of capacities that varies with speed. The capacity is fairly constant over a range of pressure. These pumps are selected by finding the curve that meets the demand requirements.

Water Mist System Pumps

Unloader valves are similar in function to relief valves. Unloader valves are not needed on foam pumps and additive pumps, only on positive displacement pumps used with water mist systems. Foam pumps are usually of the piston style or plunger type.

The relief valve must relieve 100% of the pump capacity otherwise the pressure would continue to increase and cause serious damage.

Cavitation is a concern with any pump, positive displacement or not; however, returning the relief valve discharge to suction is acceptable as long as some allowance is given for heat build-up. Starving the pump is not an issue as the complete flow is returned to pump suction.

Electric Drive For Pumps

Provide a highly reliable power supply to the electric motor driven fire pump. The standard doesn't readily identify what is considered to be a reliable supply. The power supply includes but is not limited to the service conductors, service taps, service disconnects, transformers and feeder conductors from the disconnect to the fire pump controller. Protect the power supply from exposures in the event of a fire or explosion. Maintain the electrical system in accordance with NFPA 70B with all appropriate nondestructive tests performed as necessary.

The service conductors must be in accordance with NFPA 70, Article 695.6. Locate service conductors outside. However, where impossible to do so, they may be installed inside buildings under not less than 2 in. (50.8 mm) of concrete or beneath buildings, with concrete floors not less than 2 in. (50.8 mm) thick. The intent of covering the cables is to provide physical protection and also to contain arcing that may occur. If cables pass under buildings provide access for service. Fire pump circuit conductors must be protected from the effects of fire, explosion, vehicle damage and structural collapse in the area in which they are located.

Phase converters that take single phase power and convert it to three phase power for the use of fire pump motors are not permitted because of the imbalance in the voltages between the phases when there is no load on the equipment

Normal Power

Consult both the power company and the fire department when establishing how power to the property will be isolated in an emergency.

Use electric driven fire pumps only where the electrical supply is highly reliable. When the fire pump is the sole water source, diesel driven pumps are preferred. An electric fire pump installation is vulnerable when:

- All the power is from a sole private electrical generating facility.
- The power supply from the public service electrical distribution system is not from a gridded system with multiple energy sources.
- The pump's electrical source flows through the main plant power disconnect.
- The public utility protective devices (circuit breakers or fuses) have an operating time lag shorter than the protective fuses or circuit breakers for the plant service, and the protective devices at the public service station operate before the fire pump controller circuit breaker.
- Aerial power lines are exposed by combustibles, materials with hazardous properties or by possible vehicular damage.
- Aerial power lines are exposed by trees and un-cut right-of-ways.
- The power lines to transformers pass over combustible roofs or combustible stock in open yard, or are installed in close proximity to windows or combustible buildings.
- The pump's electrical source is not entirely independent of the facility's electrical source. Interruption or loss of facility service would also result in loss of electric energy to the fire pump.
- Improper coordination of protective devices of a branch circuit allows a facility service fault to disconnect the fire pump service.
- Protection against damage from lightning strikes or surges induced by lightning or switching is inadequate or ineffective.
- The responding fire department's standard procedure is to disconnect all power to the facility before discharging water.

Establish details on the proposed routing of electrical power to the fire pump and review the routing for acceptability prior to the installation of these circuits. Connect pump circuits to electric power supplies that are dependable even under the adverse conditions that may be reasonably anticipated should a fire occur in the main property. Route wiring as far as possible from potential sources of damage by fire or other destructive forces. Prohibit power lines to the fire pump from passing through, over, or in close proximity to buildings, combustibles or vehicular traffic.

Some new cabling exists which reportedly carries a 2-hour fire rating. If this is used, it should not be routed through the building structural frame members as it could be severed during a fire/building collapse.

Other Power Sources

If the normal power supply is unreliable, use a diesel-engine pump driver. Where this is not possible, use emergency generator(s) or dual electrical supplies with a listed automatic transfer switch to maintain power to the pump motor. The transfer switch should be located in the same room as the fire pump controller.

Two Or More Alternate Sources

When one source is a dedicated feeder derived from a utility service separate from that used by the normal service, the reliability of the power available to the fire pump controller is increased significantly and special requirements are considered unnecessary.

Motors

Install motors that are listed for fire pump service following the requirements in UL 1004.

Motors on new electric driven fire pumps must be listed or the manufacturer must submit a letter of intent to list the motor and must agree to make any required changes to bring the motor installation up to the listing requirement. Existing installations will not be affected unless a motor is changed.

Several companies have listed motors, or are in the process of pursuing listing for motors for fire pump service. Listings appear in the UL Online Certifications Directory under the heading "Fire Pump Motors (QXZF)."

In addition to meeting the requirements of NFPA 20 and UL 1004, electric fire pumps must meet NFPA 70, which requires a larger field wiring compartments, or junction boxes, on all electric motor installations.

Current Limits

Select motors on the basis of required pump maximum brake horsepower. The motor’s available horsepower can be determined by the following:

Available Horsepower = Motor Rating × Service Factor.

Motors of the totally enclosed or splash-proof type are preferred. Splash-proof motors provide better protection than drip-proof motors. Drip-proof motors are susceptible to water and solid debris entering the motor when they strike the floor at angles greater than 15° from the vertical. If a drip-proof motor is used, provide water shielding that does not impede air circulation for motor cooling, or endanger personnel safety.

Service Arrangements

Verify that the pump installer works closely with a representative of the pump manufacturer to ensure proper design, installation, acceptance testing and periodic servicing.

Controller Location And Enclosures

The controller should be within sight of the motor for safety reasons and for the ability to quickly locate it in an emergency situation.

An enclosure with an IP rating of IP31 is considered to provide protection equivalent to the protection provided by a Type 2 enclosure. This is in regards to the ingress rating of the enclosure.

Connections And Wiring

Provide connections for voltage and current instruments for the proper testing of electrically driven pumps. Provide connection terminals in the pump motor controller and properly identify them. It should not be necessary to disconnect anything in the panel prior to performing a pump test. This allows for annual testing per NFPA 25 without exposing personnel to electrical arc flash hazards.

No wiring that supplies the lights in the room, jockey pump or other electrical devices should be routed through or connected to the fire pump controller.

Voltage Surge Arrestor

Surge protection is needed because all circuits are subject to power surges from lightning or switching. Provide overhead electrical feeds with appropriate lightning protection devices on both the high voltage and low voltage side of a transformer and the electrical supply to the controller. Use the appropriate surge protection for the installation. Contact an electrical engineer familiar with such installations when developing specifications and evaluating existing locations. Surge arrestors should meet the requirements for ungrounded circuit protection if an ungrounded system is used.

Circuit Breaker

Circuit breakers have both ratings and settings and it is very important to distinguish between them. Manufacturer's ratings are the appropriate classification of the device for normal continuous operation. The settings, however, are limits that cause the overload device on a breaker to trip. The concern is to prevent circuit breaker tripping for locked-rotor conditions while still allowing protection for other trip conditions. Many of the modern breakers used in fire pump service are preset.

Use circuit breakers with the following characteristics:

- A continuous current rating not less than 115% of the fire pump motor's rated full load current as shown on its nameplate. On some of the new molded-case breakers, the various values or settings may be identified by a coded number or some other mark on the breaker.
- Overcurrent sensing elements of the nonthermal type.
- Instantaneous short-circuit overcurrent protection with a trip setting not more than 20 times the full-load current rating of the fire pump motor, based on the expected starting in-rush current experienced in the motor circuit. See Section 9-5 regarding motor selection. The necessary information is shown under the "Instantaneous Trip Scale" on the nameplate.
- An interrupting capacity of the controller (circuit breaker or current limiting device) **equal to or greater than the maximum fault current possible** at the location of the breaker, as determined by the utility company or a registered professional electrical engineer.

The amount of fault current is not determined by the size of the pump motor because a short circuit can draw current far in excess of normal motor current. The size of the transformer, the size and length of the cables supplying power to the circuit breaker, the impedance of the system, and the amount of current available from the utility determine the fault current that the circuit breaker must be able to interrupt.

Occasionally the controller circuit breaker cannot handle the anticipated interrupting capacity and must be modified by the manufacturer by adding current-limiting fuses. The fuse selection must be coordinated with the breaker so that they provide the required instantaneous short circuit interrupting capacity that the circuit breaker cannot provide. For guidance on electrical coordination see PRC.5.0.4.

Locked Rotor Overcurrent Protection

For alternating current squirrel cage induction motors or wound rotor induction motors, set the overload trip mechanism at 300% of the motor full-load current. This setting is shown on the "Long Time Delay" scale on the nameplate of the overcurrent device on older controllers.

Many new controllers have preset breaker settings. At locked-rotor current, which is about 600% of the motor full-load current, the circuit breaker with this setting will trip in 8s – 20 s.

Direct current motors must have circuit breakers set for 400% of the motor full-load current to trip instantaneously at or above this setting.

Phase Reversal

Phase reversal monitoring equipment is incorporated in new listed controllers. When phase reversal monitoring equipment is installed on existing pump installations, it should continuously monitor all feeder conductors to the controller. Use equipment listed by a nationally recognized laboratory.

Following loss of transmission lines at a time of natural disaster, it is quite common for power companies to accidentally switch transmission lines feeding a facility. Repair crews are not always familiar with the distribution system.

Supervision

If a facility has a valve supervisory system, extend it to the fire pump installation. Refer to PRC.11.1.1.0.

Avoid the use of non-frangible locks. Refer to PRC.12.0.2.

Connect signal devices remote from the controller to a listed Control System Unit in accordance with NFPA 72 and PRC.11.1.1.0.

Starting And Stopping Of Pumps

Pressure-switch operated controllers are preferred. Some new pressure switches have proven to be reliable as well. Automatic remote starting can be accommodated on a pressure-switch operated controller.

Where multiple pumps in parallel are present for redundancy, start all necessary pumps in a cascading fashion at different system pressures. Arrange systems with large demands, such as deluge systems for hangars or chemical plants, to start sequentially using both a signal from the deluge system and time delays. Provide a 5 s - 10 s time delay for preventing simultaneous starting of electrically driven pumps, which reduces higher than necessary current peaks. Starting pumps at intervals reduces pressure peaks, possible high in-rush currents and possible water hammer on the discharge side of the fire pump.

Sequential starting of pumps in series is becoming more common especially in high-rise buildings. Proper sequencing is essential to the operation of such systems; upstream pumps should start first. This should also be explored when dealing with systems that require high flow rates from manual fire fighting equipment.

When automatic means of stopping is incorporated in an existing fire pump control panel, bypass or remove this feature. Use manual stopping on all new systems. Manual stopping of all pumping systems is recommended, not just the sole supply pumps as indicated here.

If a run timer is used, it should be set to allow the pump to run for 10 minutes before it ceases the operation of the pump.

Controllers Rated In Excess Of 600 Volts

The majority of electrically driven fire pump installations use low voltage controllers. High voltage controllers can be accepted for fire pump service if properly arranged. Use only listed high voltage controllers on new installations. High voltage controllers that do not have a manual mechanical control are not acceptable.

Limited Service Controllers

Installing contractors or designers should confirm that horsepower requirements are not cut too closely when using limited service equipment. Do not permit a maximum voltage drop from no load to full load of more than 5%.

Fire Pump Controller And Transfer Switch Arrangements

There are two acceptable arrangements for automatic transfer switches. In either case, the power transfer switch must be listed for fire pump service.

Lockout

Do not permit controller lockouts. A keyed disconnect could be provided if necessary. Operation of the keyed disconnect should result in an audible and visual alarm at a constantly attended location. Set up written procedures for removing protection from service. Only the facility’s loss control personnel should have access to the keyed disconnect. Use the impairment procedures outlined in PRC.1.1.0.

Manual Throttles

Manual throttles are no longer permitted on new equipment. If a manual throttle is found on a diesel engine fire pump, recommend its removal. Consult the engine manufacturer for resetting of the governor.

Speed Control Governor

Use only overspeed shutdown devices that lock out and require manual resetting. The intent is that the engine be shut down when engine speed exceeds rated engine speed by 10% to 20% and will not start again automatically until the trouble has been corrected. If there is no lockout feature and an attempt is made to restart before correcting the problem, the equipment may be damaged. This locking out can be accomplished by engine-mounted equipment or through electric circuits in the engine controller. The former is preferred since not all controllers provide the necessary circuitry.

Either mechanical or electrical overspeed switches are used. Where a centrifugal overspeed electric switch is used, a manual reset push-button may be optional. On engines, such as Cummins, that are equipped with a solenoid-operated fuel valve to stop the engine, use fuel valves of the manual reset type.

On older model engines, such as General Motors, that are provided with a solenoid-operated air damper to stop the engine, the manual reset feature of the centrifugal switch is not needed. However, arrange the air damper mechanism so it requires manual resetting. Some solenoid armatures are provided with a return-action spring that reopens the air damper as soon as power is removed from the solenoid coil. This is unacceptable. Recommend removal of the return spring from the solenoid armature. Wire the circuit to the overspeed switch to sound the alarm and light the overspeed trouble lamp but not shut down the engine.

Batteries

The engine manufacturer usually specifies the ampere-hour capacity (20-h rate) and the cold-cranking amperes at 0°F (-18°C) for the storage battery. If multiple batteries are recommended they may be arranged in series to increase the voltage, or in parallel to increase the ampere-hours and cold-cranking capacity. The pump manufacturer or its agent responsible for the entire pump unit should select the batteries that meet the engine manufacturer's requirements.

Either lead-acid or nickel-cadmium (Ni-Cad) alkaline batteries may be used for starting internal combustion fire pump engines. Lead-acid batteries are more common and have proven reliability. See PRC.5.7.4 regarding stationary batteries.

Replace batteries with the same type. A Ni-Cad battery charger is usually set to operate at a higher charge rate, which may destroy a new set of lead-acid batteries.

Do not use maintenance-free, permanently water-filled batteries for fire pump service. These batteries cannot be cycle-charged without permanent loss of capacity. It is also difficult to assess the condition of a maintenance-free battery without subjecting it to a load. Lead-acid batteries have been known to explode during charging with low levels of electrolyte.

Electric starting is preferred over air or hydraulic starting.

Engine Cooling Systems

Engines cooled by heat exchangers are preferred. Most driver manufacturers install an anode in the heat exchanger to reduce tank deterioration. Follow manufacturer's inspection and replacement requirements.

Follow the engine manufacturer recommendations regarding the cooling equipment and the coolant. Usually, water is used as the coolant because the engine is not normally located in a pump house subject to freezing. Even though antifreeze coolant is not necessary in a heated fire pump house, many installers recommend its use because of improved heat transfer. This could prevent an engine freeze-up if building heat is lost during freezing weather. Drain the coolant annually and replace with fresh coolant with a rust inhibitor. Add water-pump lubricant to the coolant unless the water pump is externally lubricated.

When diesel engine driven fire pumps operate beyond 150% of capacity, the extreme drop in operating pressure may limit the flow of cooling water to the engine heat exchanger. The resulting overheating can cause severe engine damage.

Heat Exchanger Water Supply Components

Use fully-ported, indicating valves (gate, ball, or butterfly) to facilitate servicing devices in the cooling water piping. Plug valves provide a good waterway but are subject to sticking and are not as desirable.

Flush the strainers on a quarterly basis. Since this will not remove fine fibrous material that has matted into the screen openings, remove screens and clean them before and after each capacity pump test or after the pump has been run for 3 hr or more. If the pressure regulator has a built-in strainer, clean it on the same basis.

Prove the adequacy of the cooling system by operating the engine at maximum pump horsepower (about 150% of pump capacity), long enough to demonstrate that the engine temperature will stabilize at a safe level without using the manual bypass or changing the established regulator setting.

Use automatic cooling water solenoid valve coil switch with the same voltage rating as the battery circuit. There is no need to use resistors and low voltage solenoid coils since coils of the proper voltage rating are available.

Properly protect the wiring on the engine against overheating and vibration. Insulation failure in an ungrounded coil circuit will short circuit the coil and cause the solenoid valve to close.

Provide a dependable low resistance ground return path between one of the coil terminals and the engine. In some installations, one coil terminal may be grounded to the valve body to route the current back to the battery through piping and engine. However, joint gaskets and compound in the piping can increase the resistance of this path. A separate ground wire from the coil terminal to the engine block provides a superior low resistive return path.

Ventilation

Internal combustion engines require large amounts of ventilation for combustion air, heat removal and the removal of fuel vapors. (See PRC.14.2.2.2.)

Fuel Tank Supply Location

Locate fuel tanks inside the pump room. This results in:

- Greater assurance of fast starting when the fuel is at room temperature.
- Less water condensation, which leads to corrosion, difficulty in starting and running, and freeze-up of the fuel lines.
- Easier general maintenance of the tank.
- Shorter fuel lines.
- Less chance of fuel pilfering or sabotage.

The primary fire hazard in an isolated noncombustible pump house is the diesel fuel. The probable points of ignition of a fuel fire are confined to the engine, and, if such a fire did occur, it is unlikely the fuel tank itself would be involved. If the tank did become involved, the fire on the engine, by that time, would have become so intense the engine would no longer be of any value in driving the pump. To avoid exposure from a fuel spill fire, pitch the floor away from critical equipment and drain it to an outside collection tank. Where multiple diesel engines require multiple fuel tanks in the same pump room or house, provide floor curbs enclosing a volume equal to the largest tank capacity. An acceptable alternative is to provide a double walled tank.

Fuel Piping

Some engines cannot have fuel pressure on the injectors while the engine is idle because fuel can drip into the cylinders and cause a hydraulic lock. Follow the manufacturer’s recommendations.

Copper piping has not been proven to cause problems with diesel fuels, hence it is acceptable to use copper for fuel transfer from the tank to the engine. Copper tubing can be easily collapsed by foot traffic or maintenance and should be avoided

Fuel Type

Partially filled fuel tanks result in upper tank corrosion due to moisture. This corrosion can result in dirty fuel that could clog the system.

Most diesel fuels are seasonally modified for more efficient operation. Since fire pump fuels are subject to long-term storage, fuel purchased during the summer may not flow as freely in the winter. Replace treated fuels each season. Keep fuel tanks full.

Test the fuel annually for microbial contamination. If left undetected and untreated microbial growth plugs the fuel lines and filters. Some microorganisms produce acidic by-products, which can cause corrosion damage. Once detected, they may be treated with microbicide additives. Microorganism test kits are available.

Some states have mandated low-sulfur diesel fuels that may affect engine wear. Follow the engine manufacturer's guidance.

Replace fuel filters on a periodic basis as part of a comprehensive preventive maintenance program. For proper maintenance of engine driven fire pumps see PRC.6.2.1.1 and NFPA 25.

Weekly Run

Run diesel driven fire pumps long enough to prove the suction supplies, bearings, stuffing boxes, circulating relief valves, drivers and power supplies are in good working order. A minimum of 30 min is recommended. See NFPA 25 and PRC.12.0.2 for test procedures.

Starting And Stopping

If automatic means of emergency stopping are incorporated in an existing fire pump control panel, bypass or remove this feature. Arrange all new systems for manual stopping.

Means for manual starting should be provided at the controller. The weekly program timer should not be connected as this allows the pump to start and possibly not be manned.

The six attempts to start can be accomplished by 3 starts on each battery set. This allows for some battery capacity to remain after the failure to crank cause is identified.

The pump should be manually stopped regardless if it is the sole supply.

Marking

The location of the isolating switch, which services the fire pump room should be readily marked and where practical directions as to its location posted in the pump house at the fire pump controller.

Flushing

Use the requirements in NFPA 20 for suction piping flushing capacities. In no case shall the flushing capacity be less than 150% of the rated capacity of the pump.

Field Acceptance Tests

See procedures for fire pump acceptance tests in PRC.12.0.2 and PRC.14.2.1.1.

Caution: Exercise caution when testing engine-driven fire pumps. Check electrolyte level before starting the pump. Any battery with a low electrolyte level can explode when it is overcharged or while it is drawing a high current.

Periodic Inspection Testing And Maintenance

Whenever the pump operates, a qualified operator **must be in attendance** to assure the pump and driver are operating properly. See NFPA 25 and PRC.12.0.2 for guidance on periodic testing, maintenance and inspection procedures.

Do not close the discharge valve during weekly starting of fire pumps. If there is concern about possible damage to underground piping, hydrostatically test fire protection mains that are suspect. It is best to have it fail during testing rather than during an actual emergency.

If starting of the fire pump exceeds the facility's contracted peak demand level, automatic fire pump testing may be arranged to start during nonpeak demand periods. Starting at near peak demands would result in a more severe test of the power supply.

Arrange for a service contract with a service provider who has knowledge of the maintenance requirements specified by the pump manufacturer unless the owner has a maintenance work force that is knowledgeable and proficient in the pump manufacturer's maintenance requirements.

Replace the fire pump packing every 3 yr – 5 yr, not because of wear but because of hardening and grit embedment, which abrade the shaft.

For proper maintenance of electric supplies to fire pumps see NFPA 70B and PRC.5.10. For proper maintenance of engines for fire pumps see PRC.6.2.1.1.