FIRE PROTECTION PUMPS

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1.0 SCOPE

This data sheet provides installation recommendations for property fire protection pumps. These recommendations assume the use of FM Approved equipment unless otherwise noted.

This data sheet covers the selection and installation of pumps supplying water for private fire protection. Items considered include pump house construction, suction and discharge piping, power supplies, electric drive and control, internal combustion engine drive and control, and acceptance testing. This data sheet does not cover water supply capacity and pressure requirements, nor does it cover requirements for inspection, testing, and maintenance of fire pump systems. This data sheet does not provide recommendations for the installation of electrical wiring for fire pump equipment.

1.1 Changes

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

Fire pumps are intended to supply water for the purposes of fire protection. They are a critical component in a facility's fire protection system. They are expected to automatically start upon loss of fire protection system pressure or by other automatic fire detection means. They are required to supply the necessary water flow and pressure without interruption to a facility's fire protection system under fire conditions. They are required to provide a high degree of reliability.

Only proper installation along with periodic testing and maintenance will ensure a reliable pump installation.

Great care must be taken to ensure the fire pump package components are properly selected and the installation quality is high.

Failure of a fire pump during a fire can expose the facility to catastrophic property loss.

A fire pump that is inoperative for any reason at any time constitutes an impairment to the fire protection system; therefore, manage these occurrences using the FM Global Red Tag Permit System and return the pump to service without delay.

2.2 Construction and Location

2.2.1 General

2.2.1.1 Locate the pump house to permit short and properly arranged piping. Give the highest priority to suction piping.

Fig. 1. Photo of well arranged pump room

2.2.1.2 Locate the pump in a detached building of noncombustible construction a minimum of 50 ft (15 m) away from protected buildings.

When a detached building is not feasible:

1. Locate the pump room to prevent exposure from fire and falling debris or other exposures that would damage the pump or electrical feeder cables, or prevent the pump operator from remaining near the pump during a fire.
2. Provide an access door to the pump room along a building exterior wall.
3. Protect the fire pump from all other areas of the building by 2-hour fire-rated construction. If the pump room and adjacent areas are protected with an automatic sprinkler system, the separation recommendation can be reduced to 1-hour fire-rated construction.
4. Do not locate the fire pump room within or attached to an unprotected building.

2.2.1.3 Arrange any electrical control circuit wiring that extends outside the fire pump room so that failure of that wiring (open or short circuit) does not prevent operation of the pump. A fault in these wires can cause the fire pump to start and run but cannot prevent the fire pump from starting and running. Protect all control wiring within the fire pump room that are not fault-tolerant against mechanical damage using metal conduit attached to the pump room roof or walls.

2.2.1.4 Do not use the pump room or pump house for storage purposes.

2.2.1.5 Provide automatic sprinklers over engine-driven pumps.

2.2.1.6 Provide suitable means for maintaining the temperature of a pump room or pump house, where required, above 40°F (5°C). See Section 2.8 for higher temperature requirements for diesel engines.

2.2.1.7 Provide ventilation for the pump room or pump house. See Section 2.8.5 for specific ventilation requirements for diesel engines.

2.2.1.8 To lessen the likelihood of flooding, ensure the pump house floor is at or above the surrounding ground level. Locate the pump above the 500 year flood level.

2.2.1.9 Protect the fire pump, driver, and controller against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism, and other adverse conditions.

2.2.1.10 Pitch floors for adequate drainage of escaping water away from critical equipment such as the pump, driver, controller, etc. Provide a floor drain for the pump room or pump house to allow for easy removal of water from packed seals and pressure-drop testing.

2.2.1.11 Provide artificial lighting in the pump house/room so gauges and instrumentation can be read.

2.2.2 High-Rise Buildings

2.2.2.1 Locate all fire pumps on the first floor or a basement level of the building so direct access to the pump from the street level is possible. Consider flood exposure to the pump when it is located in a below grade level.

2.2.2.2 Do not install fire pumps in series.

2.2.2.3 Design systems so pressure-reducing valves are not needed. If the use of pressure reducing valves is unavoidable, use FM Approved valves and install them per Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Service.*

2.2.2.4 Supply sprinkler system water directly from a fire pump(s), a gravity tank of sufficient capacity and height above the supplied sprinklers, or a combination of pumps and gravity tanks. See Figures 2 and 3 for typical arrangements. Size the gravity tank filling pump so that it is capable of refilling the tank in 8 hours or less.

2.2.2.5 Limit the size of fire protection system zones in high-rise buildings to a maximum of 275 ft (85 m) vertically.

- Provide each zone with its own fire pump and independent fire service connections.
- For those zones above 275 ft (85 m), use high-pressure piping and fittings at the pump discharge and the lower elevations of the building with a rated working pressure that is equal to or greater than the maximum no flow (churn) pressure of the fire pump plus the maximum anticipated static suction pressure. The rated working pressure of the pipe and fittings can be reduced at building floor levels where the pressure loss due to elevation reduces the maximum anticipated static pressure in the pipe.
- Where electric motor pump drivers are used and the height of the structure is beyond the pumping capability of the fire service apparatus, provide a reliable emergency source of power for the fire pump installation.

  Provide the emergency source of power from dedicated standby engine-driven generators or from building emergency power sources. In the latter case, size the emergency power source, so it is capable of supplying the total electrical demand, including that for the fire pump. For additional installation requirements reference Data Sheet 5-23, *Emergency and Standby Power Systems.*

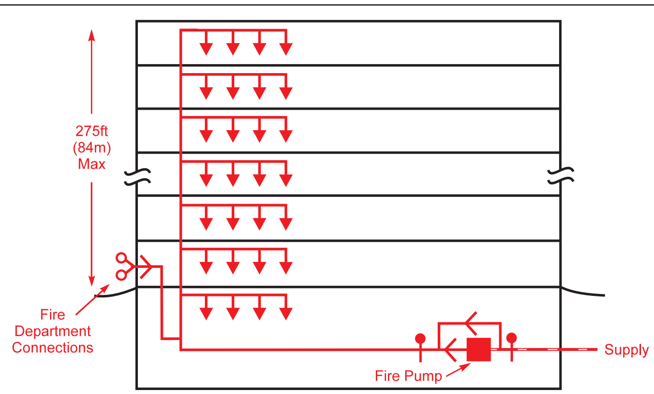


Fig. 2. Single-zone pump system

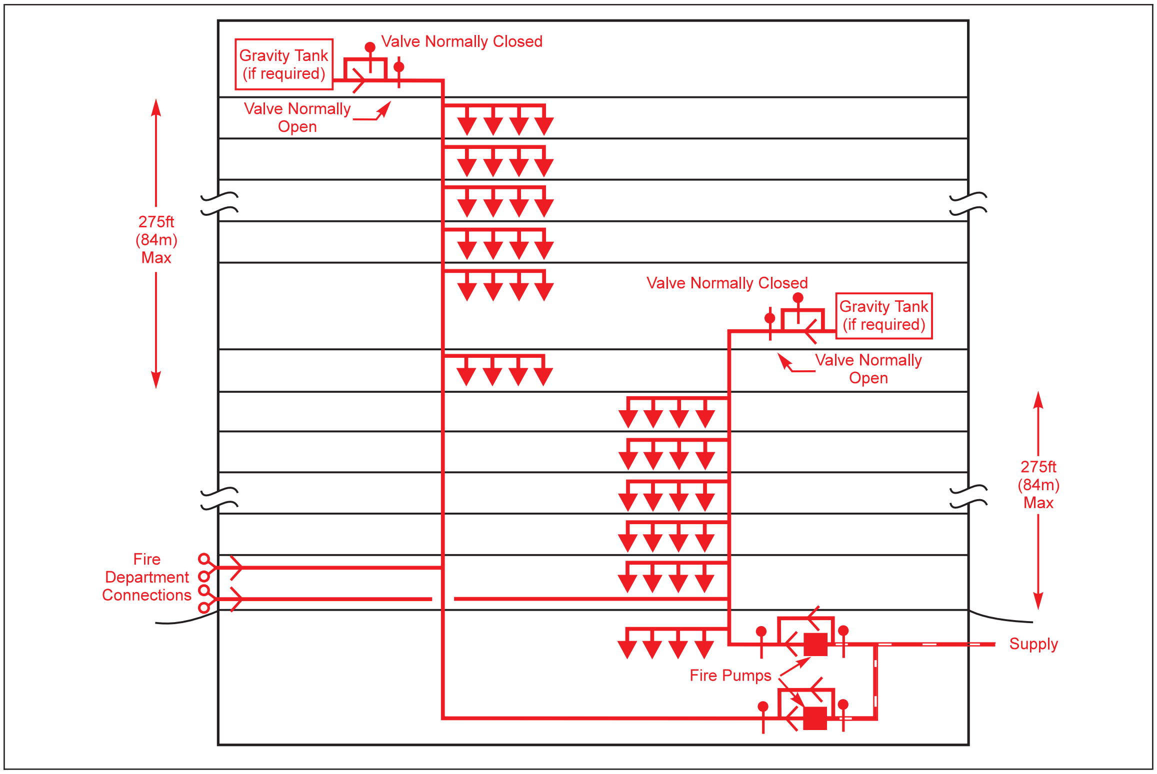


Fig. 3. Two-zone pump system with redundant supply from gravity tanks

2.3 Pump Suction and Discharge Piping

Determine the adequacy in quality, quantity, pressure, and reliability of the source of water to provide the supply for a fire pump. The source of water may be from a public or private water service main, storage tank, reservoir, etc.

Table 1. Summary of Fire Pump Piping Data

Minimum Pipe Sizes (Nominal)							
Pump Rating gpm (L/min)	**Suction in. (mm)**	**Discharge in. (mm)**	**Relief Valve in. (mm)**	**Relief Valve Discharge in. (mm)**	**Meter Device in. (mm)**	**Number and Size of Hose Valves in. (mm)**	**Hose Header Supply in. (mm)**
25 (95)	1 (25)	1 (25)	¾ (20)	1 (25)1	1 ¼ (32)	1-1 ½ (38)	1 (25)
50 (190)	1 ½ (38)	1 ¼ (32)	1 ¼ (32)	1 ½ (38)	2 (50)	1-1 ½ (38)	1 ¼ (32)
100 (380)	2 (50)	2 (50)	1 ¼ (32)	2 (50)	2 ½ (65)	2-1 ½ (38)	2 (50)
150 (570)	2 ½ (65)	2 ½ (65)	2 (50)	2 ½ (65)	3 (80)	1-2 ½ (65)	2 ½ (65)
200 (760)	3 (80)	3 (80)	2 (50)	2 ½ (65)	3 (80)	1-2 ½ (65)	2 ½ (65)
250 (950)	3 ½ (40)	3 (80)	2 (50)	2 ½ (65)	3 ½ (40)	1-2 ½ (65)	3 (80)
300 (1100)	4 (100)	4 (100)	2 ½ (65)	3 ½ (40)	3 ½ (40)	1-2 ½ (65)	3 (80)
400 (1500)	4 (100)	4 (100)	3 (80)	5 (125)	4 (100)	2-2 ½ (65)	4 (100)
450 (1700)	5 (125)	5 (125)	3 (80)	5 (125)	4 (100)	2-2 ½ (65)	4 (100)
500 (1900)	5 (125)	5 (125)	3 (80)	5 (125)	5 (125)	2-2 ½ (65)	4 (100)
750 (2800)	6 (150)	6 (150)	4 (100)	6 (150)	5 (125)	3-2 ½ (65)	6 (150)
1000 (3800)	8 (200)	6 (150)	4 (100)	8 (200)	6 (150)	4-2 ½ (65)	6 (150)
1250 (4700)	8 (200)	8 (200)	6 (150)	8 (200)	6 (150)	6-2 ½ (65)	8 (200)
1500 (5700)	8 (200)	8 (200)	6 (150)	8 (200)	8 (200)	6-2 ½ (65)	8 (200)
2000 (7600)	10 (250)	10 (250)	6 (150)	10 (250)	8 (200)	6-2 ½ (65)	8 (200)
2500 (9500)	10 (250)	10 (250)	6 (150)	10 (250)	8 (200)	8-2 ½ (65)	10 (250)
3000 (11400)	12 (300)	12 (300)	8 (200)	12 (300)	8 (200)	12-2 ½ (65)	10 (250)
3500 (13300)	12 (300)	12 (300)	8 (200)	12 (300)	10 (250)	12-2 ½ (65)	12 (300)
4000 (15100)	14 (350)	12 (300)	8 (200)	14 (350)	10 (250)	16-2 ½ (65)	12 (300)
4500 (17000)	16 (400)	14 (350)	8 (200)	14 (350)	10 (250)	16-2 ½ (65)	12 (300)
5000 (19000)	16 (400)	14 (350)	8 (200)	14 (350)	10 (250)	20-2 ½ (65)	12 (300)

Note 1: Actual diameter of pump suction flange is permitted to be smaller than the suction pipe diameter.

Support suction and discharge piping independently of the pump.

Keep the exterior of above ground steel piping painted to prevent corrosion.

Install and test all buried suction and discharge piping in accordance with Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances.*

For locations in earthquake-prone areas, refer to Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*, for additional suction and discharge pipe installation and bracing recommendations.

2.3.1 Suction Piping

2.3.1.1 Verify that the pump suction pressure remains positive at all times over the entire range of pump flow.

2.3.1.2 Ensure friction loss between any suction tank and pump suction inlet does not exceed 6 psi (0.4 bar) at the pump's 150% flow rate, which will ensure adequate net positive suction head (NPSH) required by the pump for conditions of a nearly empty tank. Include the equivalent lengths for elbows and fittings in calculations.

2.3.1.3 When the suction pipe is larger than the pump suction flange, connect them with an eccentric tapered reducer in such a way as to avoid air pockets. (See Figure 4)

2.3.1.4 Do not install elbow and tee fittings with a centerline plane parallel to a horizontal split-case pump unless the distance between the pump suction flange and the elbow or tee is greater than 10 times the suction pipe diameter. (See Figure 4)

2.3.1.5 Size the suction pipe so the velocity does not exceed 15 ft/s (4.6 m/s) when the pump is operating at 150% of rated capacity (see Table 2). For multiple pump installations with a common suction source, assume all pumps are flowing simultaneously.

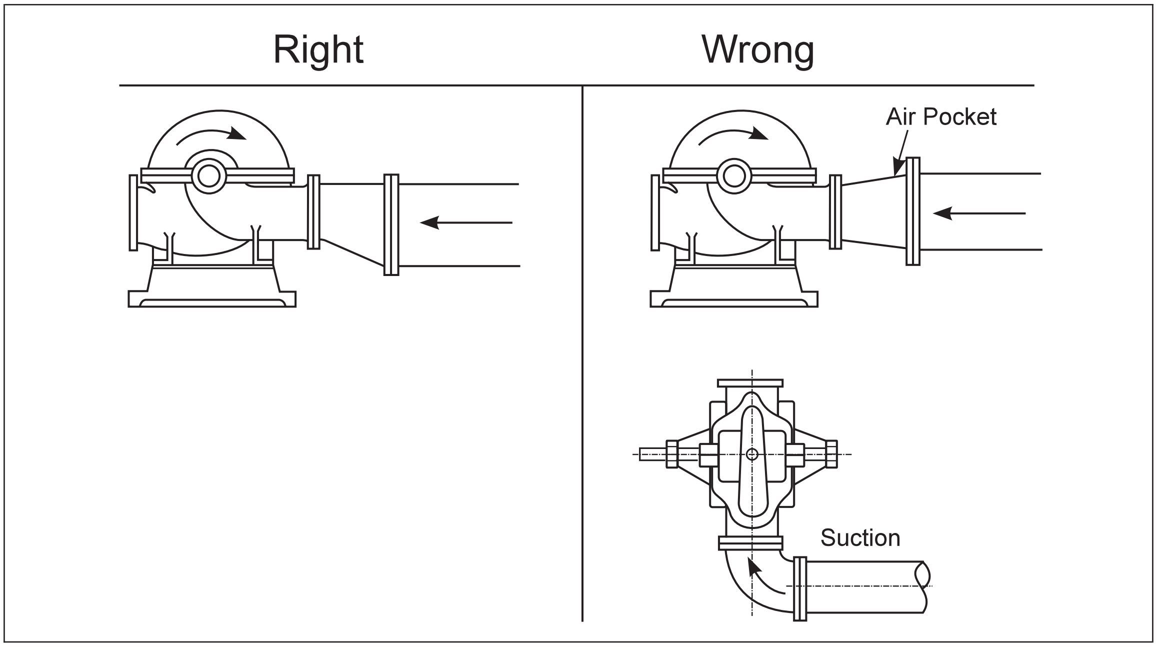


Fig. 4. (part 1) Right and wrong pump suction pipe arrangements
(See Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps for additional information)

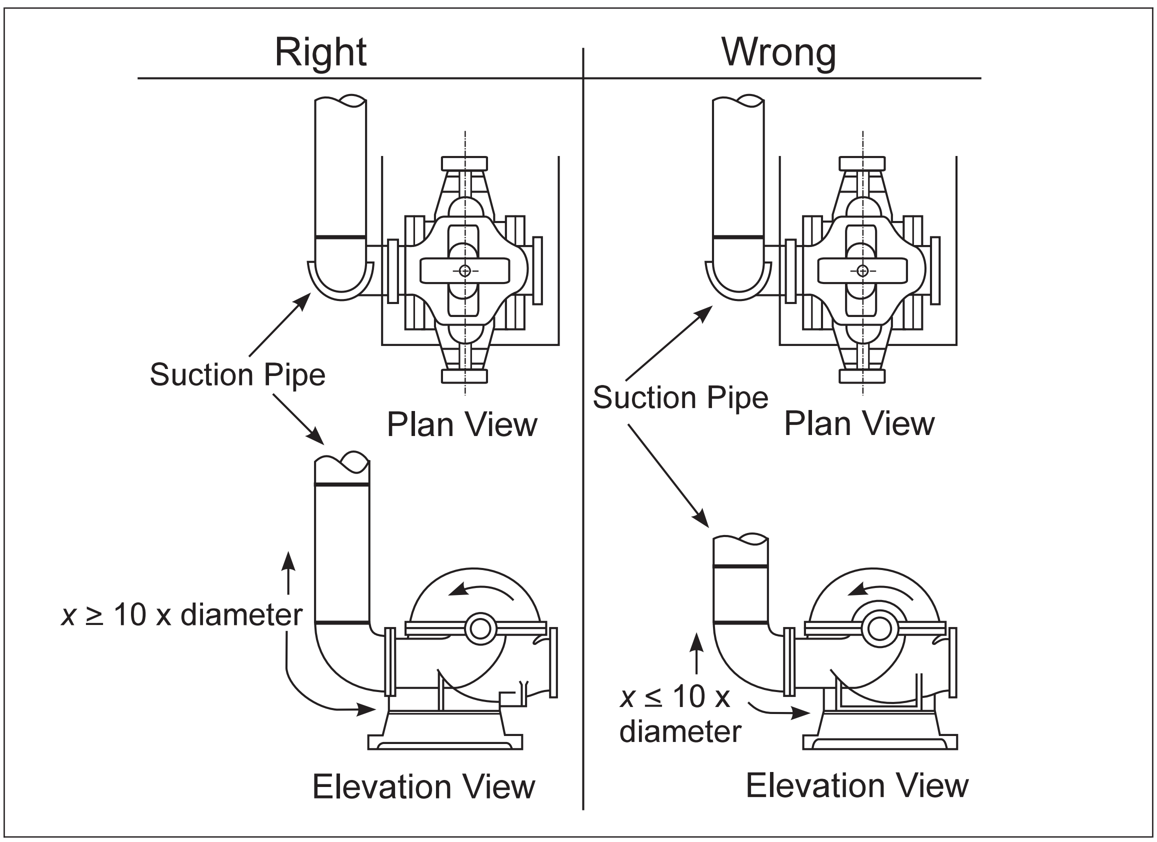


Fig. 4. (part 2) Right and wrong pump suction pipe arrangement

Table 2. Flow Required to Create 15 ft s (4.6 m s) Velocity

Pipe Size in. (mm)	Flow, gpm (L/min)	Pipe Size in. (mm)	Flow, gpm (L/min)
1 (25)	40 (151)	6(152)	1320(5000)
1 ½ (38)	95 (360)	8(203)	2340(8860)
2 (51)	155(587)	10(254)	3660(13850)
2 ½ (64)	225(850)	12(305)	5280(19985)
3 (76)	350(1325)	14(356)	6330(23960)
4 (102)	585 (2214)	16(406)	8280(31340)
5 (127)	940 (3560)		

2.3.1.6 Where the suction supply is of sufficient pressure to be of some fire protection value without the pump, install a bypass line around the pump equipped with a check valve. Size the bypass piping the same as the pump discharge pipe.

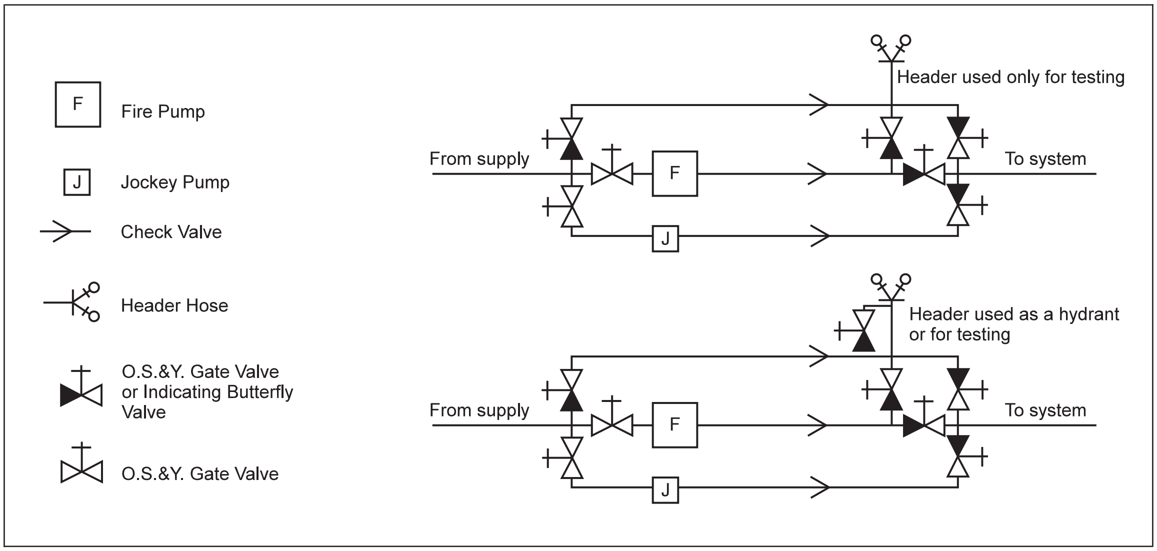


Fig. 5. Schematic diagram of suggested arrangements for a fire pump with a by-pass, taking suction from public mains

2.3.1.7 Do not install a device or assembly (including, but not limited to backflow prevention devices or assemblies) that will stop, restrict starting, or restrict the discharge of a fire pump or pump driver in the suction piping.

2.3.1.8 Locate backflow preventers on the discharge side of the fire pump whenever possible, due to the increased friction loss and the potential negative effect on pump performance.

2.3.1.9 Do not install low suction pressure cut-off or regulating valves. As a substitute, provide monitoring devices arranged to activate an alarm if the pump suction pressure or water level falls below a predetermined minimum.

2.3.1.10 Replace suction regulating valves that are not FM Approved, if required by the authority having jurisdiction, with FM Approved models.

2.3.1.11 Provide an FM Approved outside screw and yoke (OS&Y) gate valve in the suction pipe. To minimize water turbulence into the pump, install only gate-type valves within 50 ft (16 m) of the pump suction flange.

2.3.1.12 Where the suction supply is from public water mains, locate the gate valve as far as practical from the suction flange on the pump. Where it comes from a stored water container, locate the gate valve at the outlet of the container. The gate valve may be installed in the pump room on the inlet side of the eccentric suction reducer, if provided. Size the OS&Y gate valve as indicated in Table 1 column headed ‘‘Suction In’’.

2.3.1.13 Perform hydrostatic leakage testing of suction piping in accordance with Data Sheet 3-10, *Installation/ Maintenance of Fire Service Mains*. Use steel pipe with welded or threaded flanges, or mechanical groove fittings aboveground. Do not use adjustable type fittings or flexible pipe fittings unless specifically FM Approved for use with fire pumps.

Suction Screening

2.3.1.14 Where the water supply is obtained from an open source such as a pond or wet pit, or where there exists material in the water that might clog the pump or sprinkler system, provide double removable intake screens at the suction intake. Ensure these screens have an effective net area of openings of 1 in.^{2} (650 mm^2) for each gpm (3.8 L/min) at 150% of rated pump capacity.

2.3.1.15 Arrange the screens so they can be cleaned or repaired without disturbing the suction pipe.

Stored Water Supplies (Tanks and Reservoirs)

2.3.1.16 See Data Sheet 3-2, *Water Tanks for Fire Protection*, for stored water supply suction piping recommendations.

2.3.2 Discharge Piping

2.3.2.1 Install FM Approved discharge components consisting of valves such as check valves or backflow preventers, pipes, and fittings.

2.3.2.2 Perform hydrostatic leakage testing of discharge piping in accordance with Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*. Use steel pipe with welded or threaded flanges, or mechanical grooved fittings aboveground. Do not use adjustable type fittings or flexible pipe fittings unless specifically FM Approved for use with fire pumps.

2.3.2.3 Ensure the pressure rating of the discharge piping is at least adequate for the maximum pressure developed at the pump discharge, but never less than the component with the lowest-rated working pressure in the system.

2.3.2.4 Provide a means to test the fire pump installation at a minimum of 150% of the pump rated flow capacity. Outlets can be provided through the use of standard test headers, yard hydrants, wall hydrants, flow meter loop, or standpipe hose valves. Size test outlets so they are capable of water flow of not less than 175% of pump rated capacity.

2.3.2.5 If an in-line flow meter is installed, do not install a control valve within 10 pipe diameters of the flow meter inlet or within 5 pipe diameters of the outlet.

2.3.2.6 Do not install a flow meter in a closed loop piped back to the pump suction piping. With a closed loop, if the suction supply valve were to be nearly shut, the near-closure would not be detected.

2.3.2.7 Large fire protection systems sometimes experience severe water hammer caused by back flow when the fire pump shuts down. Where conditions may be expected to cause damaging water hammer, install an FM Approved anti-water-hammer device in the discharge line of the fire pump.

2.3.3 Pressure Relief Valves

2.3.3.1 Avoid the use of pressure relief valves whenever possible by using proper system design techniques to ensure the system will not experience excess pressure. Do not use the pressure relief valve to normally relieve excess pressure at lower pump flows.

2.3.3.2 Provide a main relief valve for pump installations (electric motor or diesel-driven) if the net rated shutoff (churn) pressure plus the maximum pump static suction pressure could exceed the pressure for which the system components are rated. This is intended to address temporary suction pressure surges (increases). Relief valves are normally found on electric motor driven pumps when the churn (zero flow) pressure of the pump can exceed 175 psi (12 bar) and on diesel engine driven pumps when the pressure of the pump at rated flow can exceed 125 psi (8.6 bar).

2.3.3.3 If a relief valve is required, install an FM Approved pressure relief valve as follows:

a) Size the relief valve and discharge pipe per the minimum sizes in Table 1 in Section 2.3.

b) Install the relief valve between the pump and the pump discharge check valve so it can be readily removed for repairs without disturbing the piping.

c) Arrange the relief valve discharge so it flows into an open pipe or into a cone or funnel secured to the outlet of the valve. Ensure water discharge from the relief valve is readily visible or easily detectable by the pump operator. Ensure relief valve discharge is well-contained and does not splash water into the pump room. A closed-type cone can be used if a means for detecting the flow of water through the cone is provided.

d) Pipe the relief valve cone to a point where water can be freely discharged, preferably outside the building or returned to the pump suction tank.

e) Do not pipe the relief valve to the pump suction or supply connection piping.

f) Where the supply of water to the pump is taken from a suction tank or reservoir of limited capacity, locate the relief valve discharge pipe at a point as far from the pump suction inlet pipe as necessary to prevent the pump from drafting air introduced by the relief valve discharge.

g) Do not install a shutoff valve in the relief valve supply or discharge piping.

Diesel Engine Driven Pumps

2.3.3.4 Provided a main relief valve on all diesel engine-driven fire pumps when 121% of the net rated shutoff (churn) pressure plus the maximum pump static suction pressure exceeds any system component rated pressure.

2.4 Pumps

Provide an FM Approved pump. Select the pump based on the conditions under which it will operate. Give consideration to the total amount of water and pressures required at the pump discharge for automatic sprinklers and hose streams.

Ensure pumps provide not less than 150% of rated flow at not less than 65% of the rated pump pressure. The total pressure under zero flow conditions (i.e., churn, shutoff) of an FM Approved pump will not exceed 140% of pump rated pressure.

2.4.1 Split Case, End Suction, and In-Line Centerfugal Pumps

2.4.1.1 Do no use these pumps where a static suction lift is required.

2.4.1.2 Ensure the pump has an air-release valve having ½ in. (12.7 mm) minimum diameter discharged to atmosphere. End suction pumps with a top discharge, or vertically mounted split case pumps, will naturally vent the air and do not require an air-release valve.

2.4.1.3 Install a pipeline strainer for any pump installations that require removal of the driver to clear rocks or debris from the pump impeller. Install the strainer a minimum of 10 pipe diameters from the suction flange.

2.4.2 Vertical Shaft Turbine-Type Pumps

2.4.2.1 Use a vertical shaft turbine-type pump where the water supply level is located below the discharge flange or the water supply pressure is insufficient for supplying water to the fire pump suction.

2.4.2.2 Ensure the pump bowl assembly is submerged below the suction source surface to a sufficient depth to meet the manufacturers' minimum submergence requirement. The requirement must be met at the minimum water depth that includes tidal suction sources or empty tank conditions.

2.4.2.3 Do not include the water volume below the pump's minimum submergence requirement when determining the water supply duration.

Right Angle Gear Drives

2.4.2.4 Use an FM Approved gear drive sized so both the maximum power required by the pump and the maximum thrust forces generated by the pump are less than or equal to the gear drive nameplate rating.

2.4.2.5 For diesel-driven vertical turbine pumps, verify a mass elastic torsional analysis of the system (engine, coupling, gear drive, and pump) has been conducted to ensure there are no damaging stresses or critical speeds in the range of 25% above and below the operating speed of the system components.

2.4.3 Positive Displacement Pumps

2.4.3.1 Positive displacement pumps are used for pumping water (water mist), foam concentrates, or additives. Consider the liquid viscosity as part of the pump selection.

2.4.3.2 Provide a pressure relief valve on the pump discharge capable of relieving 100% of the pump capacity. Set the pressure relief valve to relieve at or below a pressure equal to the lowest rated working pressure of any component in the system, and above the demand pressure.

2.4.3.3 Provide positive displacement pumps with an unloader valve that remains open during the pump starting sequence until the pump driver is at operating speed.

2.4.3.4 Provide positive displacement pumps with a removable and cleanable suction strainer installed at least 10 pipe diameters from the pump suction inlet. Consider suction strainer pressure drop in hydraulic calculations to ensure sufficient NPSH is available to the pump. Ensure the net open area of the strainer is at least four times the area of the suction piping. Ensure strainer mesh size is in accordance with the pump manufacturer's recommendation.

2.4.4 Mounting, Coupling, and Alignment

2.4.4.1 Mount the pump and driver securely to a solid foundation on a common base plate.

2.4.4.2 Provide a foundation sufficiently substantial to form permanent and rigid support for the pump and driver base plate.

2.4.4.3 Connect the pump and driver with a rigid coupling, flexible coupling, or flexible connecting shaft Do not use all elastomeric (plastic) couplings. An all elastomeric coupling is one that relies solely on an elastomeric material for power transmission. Examples of recommended couplings are: pin and bushing, jaw, disc, drive shaft, or steel-grid-type couplings where the drive components are metallic. Direct connection or "close-coupling" of the pump and driver is acceptable for electrically driven, in-line, vertically mounted, horizontal split case, and end-suction pumps.

2.4.4.4 Align pumps and drivers on separately coupled-type pumps in accordance with the coupling and pump manufacturers' specifications.

2.4.4.5 For locations in earthquake-prone areas, refer to Data Sheet 2-8 for additional equipment securement and bracing requirements.

2.4.5 Mechanical Seals

2.4.5.1 Only use pumps that have been specifically FM Approved for use with mechanical shaft seals.

2.4.5.2 Only use pumps equipped with mechanical seals in systems that meet the following criteria:

1) The suction source water is clean. Do not use pumps with mechanical seals in systems where any water source is an open body of water (e.g., retention pond, lake, or river).

2) The suction pressure is positive under all conditions of pump flow.

3) A spare split mechanical seal set is maintained on site.

4) Weekly testing of the pump is conducted.

2.5 Pump Sizing

2.5.1 Size the pump to meet the maximum required flow and pressure demand for the system.

2.5.2 For centrifugal pumps, use a maximum of 140% of the pump rated flow capacity to meet the combined system demand and hose streams (if also supplied by the fire pump).

2.5.3 Size the pump driver equal to or larger than the maximum peak power required by the pump at any point over its entire flow range. See Sections 2.8.2 and 2.9.1 for more information.

2.5.4 Size a booster pump's rated pressure based on the minimum anticipated suction pressure at the maximum required flow demand of the system. Review the daily and seasonal fluctuations in supply pressure to determine the minimum anticipated pump suction pressure.

Table 3. Approximate Power Required to Drive Fire Pump. For specific power requirements consult manufacturer.

Capacity gpm (L/min)	Pressure psi (bar)	Approximate Brake Horsepower (kW)
500 (1900)	75 (5)	30-40 (22-30)
	100 (7)	50-60 (37-45)
	125 (9)	60-70 (45-52)
750 (2800)	75 (5)	50-60(37-45)
	100 (7)	60-75 (45-56)
	125 (9)	75-125 (56-93)
1000 (3800)	75 (5)	90-100 (67-75)
	100 (7)	75-100 (56-75)
	125 (9)	125 (93)
1500 (5700)	75 (5)	90-100 (67-75)
	100 (7)	125 (93)
	125 (9)	150-200 (112-150)
2000 (7600)	75 (5)	100-125 (75-93)
	100 (7)	150-200(112-150)
	125 (9)	200-250 (150-190)
2500 (9500)	75 (5)	125-150 (93-112)
	100 (7)	200 (150)
	125 (9)	250-300 (190-225)

2.6 Pump Starting and Control

Provide an FM Approved fire pump controller to start and control the pump driver.

Arrange fire pumps to start automatically at a predetermined water pressure or by water flow.

Arrange fire pumps supplying water to sprinklers and hoses for automatic starting and manual stopping. Manual stopping requires that whenever the pump starts, the pump house is visited by appropriate personnel to determine that the pump package is running properly, and to ensure the pump is not stopped until it is ascertained that pump starting causes have returned to normal and any fire emergency has been successfully resolved.

Maintain underground mains and provide a pressure maintenance (jockey) pump. Do not use the fire pump as a pressure maintenance pump.

2.6.1 Sequence Starting

2.6.1.1 If more than one pump arranged in parallel is required to operate to meet the water demand, set the pumps to prevent simultaneous starting. Arrange the pump-starting sequence so the maximum time between pump starts is 10 seconds. Arrange the pump starting so failure of a pump to start does not prevent subsequent pumps from starting.

2.6.2 Automatic Weekly Test Timers

2.6.2.1 If an automatic weekly test feature is provided by the fire pump controller, do not rely on it to test the pump without supervision. Arrange for appropriate personnel to respond and be in attendance for all pump-running situations, including scheduled tests, to monitor proper operation of the pump unit during the test, identify and correct problems, and to ensure the unit is left in proper operating condition after the test.

2.6.3 Run-Period Timers

2.6.3.1 Arrange the pump controller for manual stopping. This requires the controller run-period timer (if provided) to be defeated. Do not set the run-period timer to “zero” as a means of converting from automatic stop to manual stop. Use the correct method for defeating the controller run-period timer, which can be found in the operation and maintenance manual of all FM Approved controllers.

2.6.4 Pressure Switches

For all pump installations (including jockey pumps), each controller will have its own individual pressure-sensing line.

2.6.4.1 Connect the controller pressure-sensing line for each pump (including jockey pumps) between the pump’s discharge check valve and the discharge control valve. Ensure the line is made of a corrosion-resistant material (brass, copper, or series-300 stainless steel pipe or tube and fittings) and has a minimum internal diameter of ½ in. (12.7 mm) nominal size.

2.6.4.2 Do not install a shutoff valve in the pressure-sensing line. Valves that release water in the pressure-sensing line to facilitate pump testing are acceptable.

2.6.4.3 For pressure-surge dampening, install two check valves in the pressure-sensing line at least 5 ft (1.5 m) apart with a single 3⁄32 in. (2.4 mm) hole drilled in the check valve clapper to serve as dampening. Install the check valve flow arrow toward the sense line connection at the pump discharge.

2.6.4.4 For pressure switches with a high and low actuation settings, adjust the switch so the low adjustment setting initiates pump starting.

2.6.4.5 Set the start pressure of the fire pump as close as possible to the expected no flow (churn) pressure developed by the fire pump to avoid water hammer.

2.6.4.6 Arrange the fire pump system, when started by pressure drop, as follows:

1. The jockey pump start point equals the pump pressure at churn (zero flow) plus the maximum static pump suction pressure plus 5 psi.

2. The jockey pump stop point is 10 psi (70 kPa) more than the jockey pump start point.

3. The fire pump start point is 5-10 psi (35-70 kPa) less than the jockey pump start point. Use 10 psi (70 kPa) decrements for each additional pump start.

Example:
Pump: 1000 gpm, 80 psi pump with churn pressure of 95 psi.
Suction Supply: 50 psi from city-minimum static.
60 psi from city-maximum static.
Jockey pump start = 95 + 60 + 5 = 160 psi
Jockey pump stop = 160 + 10 = 170 psi
Fire pump start = 160 – (5-10) = 150-155 psi
(For SI units: 1 psi = 0.0689 bar.)

2.7 Electric Motor-Driven Pumps

2.7.1 Power Supply Arrangement

2.7.1.1 Carefully review the reliability of the electric power source. Consider the possibility of fire damaging power lines located either on the property or on adjacent properties.

2.7.1.2 Supplement unreliable power sources with a second, independent source of power, such as an emergency generator or alternate utility connection, or provide a diesel engine-driven pump.

A reliable power source has infrequent power disruptions from environmental or man-made conditions. An electric power source that has disruptions lasting longer than 8 hours three or more times in a 12-month period is considered unreliable. More frequent short-term outages would also be considered unreliable.

2.7.1.3 Connect the electric motor fire pump controller feeder circuit directly to the facility power source ahead of all other facility power loads or as required per the applicable electrical code. If the fire pump motor utilization voltage is different to the facility's utilization voltage, provide a dedicated transformer to supply the fire pump motor and its associated loads. See Figure 6.

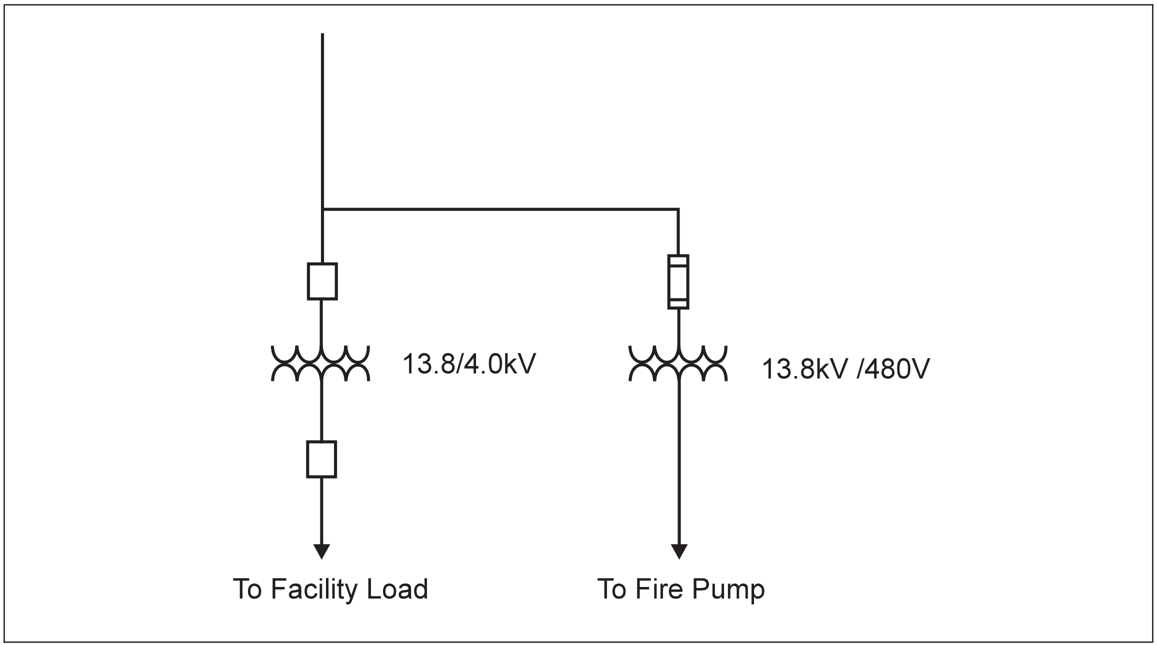


Fig. 6. Typical Dedicated Fire Pump Motor Electrical Feeder

2.7.1.4 Ensure circuits feeding the fire pump motors(s) and their accessories are separate from the circuits supplying other facility loads and are dedicated only to the fire pump motor and its associated loads. Arrange the power supply to the fire pump motor and its associated loads such that disconnection of the main facility power does not interrupt power to the fire pump motor and its associated loads. See Figure 7.

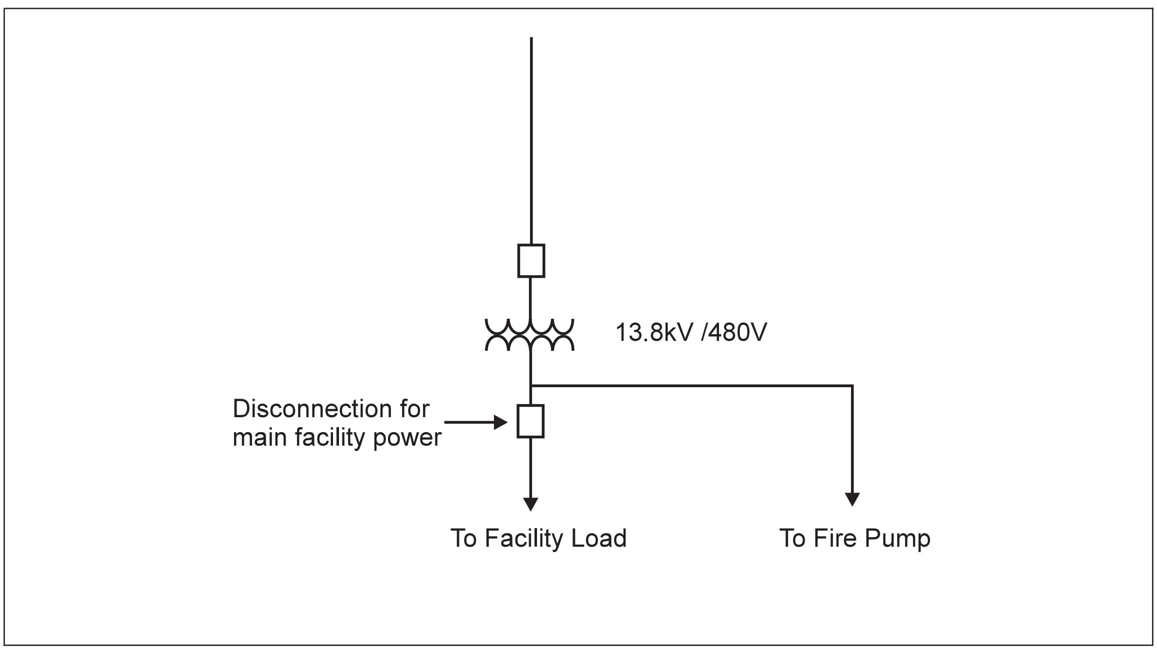


Fig. 7. Typical fire pump electrical feeder connected ahead of all other facility loads

2.7.1.5 Protect the fire pump motor feeder cables from damage by fire, structural failure, natural hazards, and operational accidents. The preferred method to protect fire pump feeder cables is to bury the cables underground. Other methods of installing the fire pump feeder cables are listed in descending order of preference:

(1) Encase the cables in a minimum of 2 in. (50 mm) of concrete.

(2) Use mineral insulated "MI" power cable.

(3) Use rigid noncombustible conduit on the outside of an exterior wall of a fire-resistive building.

(4) Use rigid noncombustible conduit over or inside a fire-resistive building having noncombustible occupancy.

(5) Use messenger-supported cables over the roof of a fire-resistive building having noncombustible occupancy.

(6) Install cables overhead on utility poles away from protected buildings where not exposed to potential damage from yard storage or facility operations.

2.7.1.6 Do not install feeder cables over or through a combustible building or any building with combustible occupancy.

2.7.1.7 Eliminate hazards from stored combustibles, objects, equipment, or other sources that may expose the electrical service to fire or mechanical damage.

2.7.1.8 Size fire pump controller feeder cable conductors based on local electrical codes but, at minimum, ensure they are capable of carrying 125% of the fire pump motor-rated current.

2.7.1.9 Arrange the power supply so the voltage at the controller line terminals does not drop more than 15% below the controller-rated voltage during automatic motor-starting. This is not required when the manual emergency start feature of the controller is used; however the power supply must provide sufficient voltage to allow for emergency manual starting. Ensure the voltage at the motor terminals does not drop more than 5% below the voltage rating of the motor when the motor is operating at 115% of the full-load current rating of the motor.

2.7.1.10 Size the primary fuses that protect transformers supplying power to the fire pump controller so that the fuses will not open under motor locked-rotor current conditions in addition to any other normal electrical loads for an indefinite period.

2.7.1.11 Do not install ground-fault protection in any portion of the circuit that supplies power to the fire pump controller. If ground fault protection must be provided per the authority having jurisdiction, set the ground fault protection to trip at currents above the motor locked rotor current. Also set the ground fault protection so it will not operate on motor start-up. Conduct a reliability study of any fire pump circuit provided with ground fault protection.

2.7.2 Electric Motors

2.7.2.1 Ensure electric motors for fire pump service are designed in accordance with either the National Electrical Manufacturers Association (NEMA) Standard MG-1 or the International Electrotechnical Commission (IEC) Standard IEC34-1.

2.7.2.2 Electric motors for fire pump service require a winding insulation temperature rating of NEMA/IEC Class B 130°C (266°F) or greater.

2.7.2.3 To protect against water ingress, electric motors for fire pump service require minimum rating equivalent to a NEMA open drip poof type or have a minimum IEC rating of IP22.

2.7.2.4 Size the motor in horsepower or kilowatts such that the maximum motor current in any phase under any anticipated condition of pump load and voltage unbalance does not exceed the motor rated full-load current multiplied by the motor service factor.

2.7.2.5 Ensure that the rated motor power provided is on a continuous (not intermittent) duty basis.

2.7.3 Electric Motor Controllers

2.7.3.1 Provide an FM Approved fire pump controller.

2.7.3.2 Locate the controller within sight of and as close as practical to its motor.

2.7.3.3 Provide remote electronic monitoring of the fire pump controller unless constant attendance and prompt personnel response can be ensured at all times.

2.7.3.4 Do not use the fire pump controller as an electrical junction box to supply power to other pump room equipment. This includes pressure maintenance (jockey or make-up) pump(s).

2.7.3.5 Size the pump controller to be greater than or equal to the motor size in horsepower or kilowatts.

Limited Service Controllers

2.7.3.6 Do not use limited service controllers for fire pumps supplying primary building sprinkler protection. The use of this controller type is limited to 30 hp (22 kW) and less and may be suitable for use to control additive (foam) pumps, other special protection system pumps, or standpipe hose connection pumps.

2.7.4 Power Transfer Switches

2.7.4.1 Use only FM Approved combination fire pump controller and transfer switches or stand-alone fire pump power transfer switches.

2.7.4.2 Size the power transfer switch to have a power rating at least equal to the motor power or, where rated in amperes, not less than 115% of the motor full-load current. Ensure the power transfer switch is suitable for switching the motor locked rotor current.

2.7.4.3 If an alternate power source is required for reliability, ensure the positions of the transfer switch and the alternate power source switch are remotely supervised. Provide a suitable over-current protection device for the transfer switch if the short circuit current available from the alternate source exceeds the fire pump motor locked rotor current. Size the over-current protection device for the alternate power source to carry the fire pump motor lock rotor current plus any other pump room loads indefinitely.

2.7.5 Variable Speed Electric Pumps

2.7.5.1 Provide a system pressure relief valve as specified in Section 2.3.3.

2.7.5.2 Use only FM Approved variable speed electric fire pump controllers.

2.7.5.3 Limit the cable length between the controller and the motor to 100 ft (30 m) maximum.

2.7.5.4 In addition to the motor requirements of Section 2.7.2, use only motors that are specifically “inverter duty” rated. In addition, do not use the motor service factor when sizing the motor. Use only the rated power on the motor nameplate.

2.7.5.5 Ensure operation at minimum speed does not result in overheating of the motor.

2.7.5.6 Ensure the variable speed pressure sensor is dedicated to the variable speed control and independent of the pressure starting switch. Do not use a common pressure control for multi-pump installations.

2.7.5.7 Ensure the regulated target pressure is greater than the maximum system demand pressure at the maximum required flow.

2.7.5.8 During pump churn (no flow) testing, ensure the motor speed is regulating the pump discharge pressure to within 5% of target pressure (175psi [12 bar] is typical).

2.7.5.9 Ensure the controller output power frequency never exceeds the controller input line frequency (50 Hz or 60 Hz).

2.7.5.10 Record the pressure limit setting and pump start pressure in or on the fire pump controller cabinet. Set the controller for manual stopping only.

2.8 Diesel Engine-Driven Pumps

Use only FM Approved diesel engines intended for fire pump service. FM Approved engines are one of the following types:

a. Closed circuit, liquid-cooled with pump discharge water heat exchanger (heat-exchanger-cooled); or

b. Closed circuit, liquid-cooled with a radiator and engine driven fan (radiator-cooled).

2.8.1 Engine Sizing

2.8.1.1 Deduct 3% from the rated engine power for diesel engines for every 1,000 feet (305 m) altitude above 300 ft (90 m).

2.8.1.2 Do not de-rate engine power for high temperature unless combustion air temperatures can exceed 105°F (40°C). Deduct 3% from rated engine horsepower at temperatures equal to or greater than 105°F (40°C). Limit the maximum ambient temperature to 120°F (49°C). Consider pump room temperature rise from engine heat when determining the maximum combustion air temperature.

2.8.1.3 Where right-angle gear drives are used between the vertical-turbine pump and its driver, increase the horsepower of the pump to allow for power loss in the gear drive. See Section 2.4.2 for more information on vertical turbine pumps and right angle gear drives.

2.8.1.4 After the above de-rating, ensure the engine de-rated power is equal to or greater than the power required to drive the pump at its rated speed under any conditions of pump load.

2.8.2 Diesel Engine Controller

2.8.2.1 Use FM Approved fire pump controllers.

2.8.2.2 Locate controllers as close as practical and within sight of the engine.

2.8.2.3 Provide remote electronic monitoring of the fire pump controller unless constant attendance and prompt personnel response can be ensured at all times.

2.8.2.4 Do not use the fire pump controller as an electrical junction box to supply power to other pump room equipment. This includes pressure maintenance (jockey or make-up) pump(s).

2.8.3 Power Failure Starting

2.8.3.1 Ensure pump room temperature is maintained above 40°F (4°C) and the diesel engine cooling water remains above 70°F (20°C) during power failures. To accomplish this, the diesel engine may be arranged to automatically start; however, provide this arrangement only if an immediate response from trained personnel can be guaranteed. Before arranging a fire pump for automatic starting upon power failure, give consideration to abnormal facility shut-down, such as during severe natural hazard events, when a power failure is likely and a trained response would be unlikely. If the pump is not supervised and starts on power failure, depletion of the fuel supply and/or pump overheating can occur.

2.8.4 Fuel Tank and Piping

2.8.4.1 Store the diesel engine fuel in a double-walled steel tank or a concrete vault style tank.

2.8.4.2 Provide each fuel tank with individual fill, drain, and vent connections.

2.8.4.3 Locate diesel fuel storage tanks inside the pump room. Extend the tank fill and vent lines outdoors. If they cannot be located in the pump room, provide a reliable means of maintaining the fuel storage tank temperature above 40°F (4°C).

2.8.4.4 Provide spill containment curbing around indoor fuel tanks. Design the curbing around the fuel tank to contain the entire contents of the tank plus 2 in. (5 cm) freeboard.

2.8.4.5 Do not use glass or plastic liquid level sight tubes on the fuel storage tank.

2.8.4.6 Size the fuel supply tank(s) for a minimum of 8 hours of engine run time, plus 5% volume for expansion and 5% volume for sump. Reserve the fuel supply tank and fuel exclusively for use by the fire pump diesel engine.

2.8.4.7 Where prompt replenishment of fuel supply is unlikely, provide an on-site reserve supply tank along with facilities for fuel transfer to the supply tank.

2.8.4.8 For multi-pump installations, provide separate fuel lines and separate fuel supply tanks for each engine.

2.8.4.9 Do not connect the fuel supply line to the bottom of the tank. Locate the fuel supply line tank connection so 5% of the tank volume is reserved as a sump volume not usable by the engine. In addition, arrange the fuel supply line tank connection so that its relative height is higher than the engine fuel pump. Verify the engine manufacturer's fuel pump maximum static pressure is not exceeded when the level of the fuel in the tank is at maximum.

2.8.4.10 Provide the fuel line in Section 2.8.4.9 with a ¼-turn ball valve at the point of connection to the tank. Lock this valve open.

2.8.4.11 Provide a mechanical guard or use protected piping for all exposed fuel lines.

2.8.4.12 Provide flame-resistant flexible fuel hoses rated for this service at the engine for connection to the fuel system piping.

2.8.4.13 Install the fuel return line per the engine manufacturer's recommendation. Do not install shutoff valves in the fuel return line to the tank.

2.8.4.14 Use only the type and grade of diesel fuel specified by the engine manufacturer. Ensure the minimum pour point and cloud point of the fuel is 30°F (-1°C) or less. Do not use biodiesel fuels due to fuel stability problems when stored for long periods of time.

2.8.4.15 Where an electric solenoid valve is used to control the engine fuel supply, arrange it to be capable of manual mechanical operation or of being manually bypassed in the event of control circuit failure.

2.8.4.16 For specific recommendations addressing the fire exposure of the diesel fuel tank installation, see Data Sheet 7-88, *Ignitable Liquid Storage Tanks.*

2.8.5 Ventilation

2.8.5.1 Provide room ventilation that ensures:

a. The maximum temperature under any conditions is maintained at 120°F (49°C) or less when measured at the combustion air cleaner inlet.

b. Sufficient air for engine combustion.

c. Removal of any hazardous vapors.

d. Sufficient room air changes for radiator-cooled engines.

2.8.5.2 For heat exchanger-cooled diesel engines, provide ventilation openings in the pump room of at least 0.75 in.^{2}/Hp (6.5 cm^2/KW).

2.8.5.3 Duct cooling air from the radiator to outside the pump room through free-swinging louvers having an effective net area of at least one and one-half times the area of the radiator air outlet.

2.8.5.4 Interlock the pump room ventilation system (louvers and fans) with engine operation. Do not use a thermostat to control room ventilation. For optimum room ventilation, locate the air supply ventilator and air discharge vent on opposite walls.

2.8.6 Manual Starting

2.8.6.1 Provide two manual-starting contactors (one for each battery) and the required fuel and cooling controls at the engine, independent of the fire pump controller.

2.8.6.2 Ensure the sequence for emergency manual operation (arranged in step-by-step manner) is posted on the fire pump engine, and the pump operator is familiar with the procedure.

2.8.7 Batteries

2.8.7.1 Provide each engine with two separate starting batteries. Size each battery to have twice the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer (120 rpm is typical) through a 3-minute “attempt to start” cycle (15 seconds cranking and 15 seconds of rest, in six consecutive cycles) at a temperature of 40°F (4.5°C). In addition, ensure the batteries are capable of starting the engine for a minimum of 90 hours following a power failure.

2.8.7.2 Ensure lead-acid, nickel-cadmium, and other kinds of batteries are compatible with the battery chargers in the controller. Install and maintain them in accordance with the battery manufacturer’s instructions.

2.8.7.3 Do not place starting batteries directly on the pump room floor. Locate the batteries above the floor, preferably on a supporting rack, secured against movement, and located where they will not be subject to excessive temperature, vibration, mechanical injury, or flooding by water. Locate the batteries so they are readily accessible for servicing. Determine the minimum battery cable size and maximum length based on the engine manufacturer’s instructions in the engine manual.

2.8.7.4 Do not install current-carrying conductors (battery and signal cables) to and from the engine less than 12 in. (300 mm) above floor level.

2.8.8 Engine Cooling

Open-Loop Heat Exchanger-Cooled Engines

2.8.8.1 Connect the cooling water supply piping for heat exchanger-type engine cooling systems directly to the discharge of the pump, at a point before the pump discharge check valve. Use rigid piping for this connection.

2.8.8.2 Provide the cooling water supply piping with the following:

a) a label showing the intended direction of flow;

b) an indicating manual shutoff valve;

c) an FM Approved flushing-type strainer;

d) a pressure regulator;

e) an automatic valve;

f) a second indicating manual shutoff valve; and

g) a pressure gauge towards the engine after the last manual valve.

An automatic valve (e) is not required on vertical shaft turbine-type pump or any other pump when there is no pressure in the discharge when the pump is idle.

2.8.8.3 Provide a bypass line with manual valves, flush-type strainer, and a pressure regulator around the manual shutoff valve, strainer, pressure regulator, and automatic valve.

2.8.8.4 Size the pressure regulator so it is capable of flowing approximately 120% of the cooling water required when the engine is operating at maximum power. Additionally ensure the regulator can supply the required cooling water flow at 65% and 140% of the pump’s rated discharge pressure. Base the cooling water flow on the engine manufacturer’s instructions, taking into account the potential maximum cooling-water temperature.

Closed-Loop Radiator-Cooled Engines

2.8.8.5 Ensure adequate air flow through the room and radiator. For a radiator-cooled engine, an engine-driven fan will push the air through the radiator that must be exhausted from the room via the air discharge ventilator.

2.8.8.6 Obtain combustion and cooling air from outside the pump room through free-swinging louvers having an effective net area of at least two times the area of the radiator air outlet.

2.8.8.7 Duct cooling air from the radiator to outside the pump room through free-swinging louvers having an effective net area of at least one and one-half times the area of the radiator air outlet.

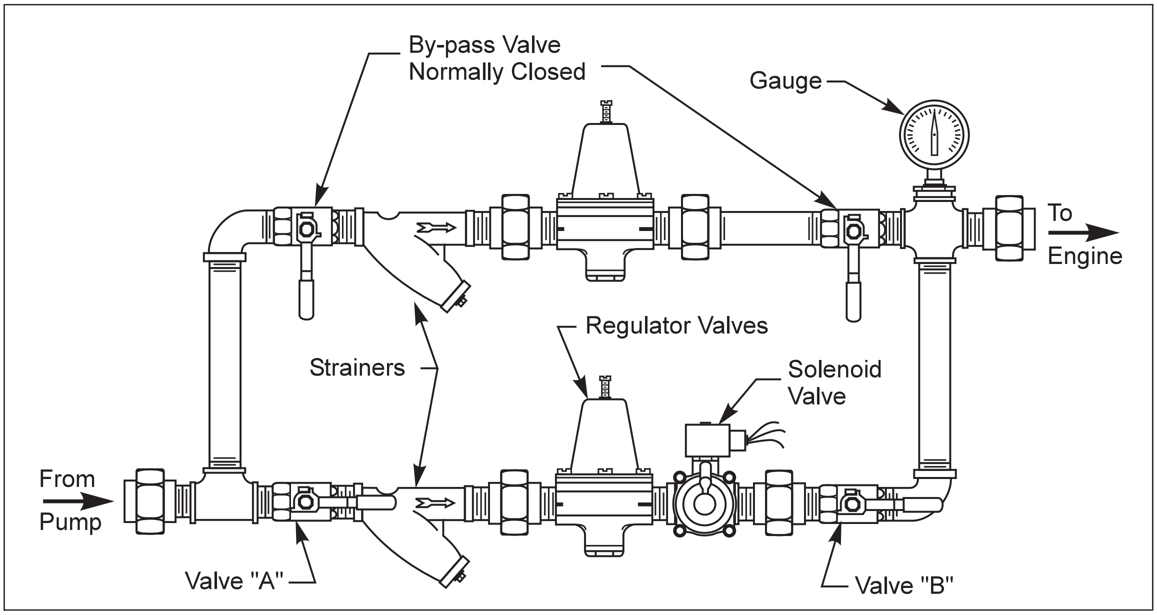


Fig. 8. Diagram of a typical heat exchanger cooling water piping arrangement.

2.8.9 Diesel Engine Speed

2.8.9.1 Ensure the diesel engine speed is set within 10% of the speed marked on the pump nameplate. Ensure the pump flow and pressure output exceeds the maximum facility fire protection water demand. Adjust the speed governor to correct if necessary. Do not exceed the diesel engine nameplate rated speed by more than 10%.

2.8.10 Variable-Speed Diesel Pumps

2.8.10.1 Provide a system pressure relief valve as recommended in Section 2.6.

2.8.10.2 Ensure the sense line for pressure control purposes is a minimum of ½ in. (12.7 mm) nominal inside diameter. Connect the sense line on the pump discharge piping between the pump and the discharge check valve.

2.8.10.3 Ensure the target pressure limit is greater than the maximum system demand pressure at the maximum required flow.

2.8.10.4 During pump churn (no flow) testing, ensure the engine speed is regulating the pump discharge pressure to within 5% of target pressure (175 psi [12 bar] is typical).

2.9 Acceptance Testing

See Appendix C for acceptance test procedures.

2.9.1 Obtain a copy of the manufacturer's certified pump test characteristic curve for comparison to the results of the field acceptance test. The fire pump as installed should equal or better the pump performance as indicated on the manufacturer's certified shop test curve within the accuracy of the test equipment. If this is not the case, investigate the cause of the discrepancy and correct it.

2.9.2 Ensure the fire pump performs at minimum, rated, and peak loads without overheating or damage of any component.

2.9.3 Ensure vibrations of the fire pump assembly are not of a magnitude to cause damage to any fire pump component.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Supplemental Information

3.1.1 Construction and Location

Holes and penetrations through pump room fire walls can be packed with mineral wool or other suitable material held in place by pipe collars on each side of the wall.

It is desirable to provide clearance of 1 in (25 mm) or more for pipes passing through foundation walls or pit walls into the ground, but ensure the penetrations are sealed watertight. Space around pipes passing through pump room walls or pump house floors may be filled with asphalt mastic.

For earthquake protection see Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems.*

In pump rooms, vertical shaft turbine-type pumps may require a removable panel in the pump house roof to permit the pump to be removed for inspection or repair. Provide proper clearances to equipment as recommended by the manufacturer's drawings.

For maximum reliability and equipment life, pump rooms and pump houses must be kept dry and free of condensate. A room heater may be required to accomplish this.

3.1.2 High-Rise Buildings

Fire pumps may be used for automatic sprinkler systems, standpipe and hose systems, and combined systems (automatic sprinkler systems having standpipe type hose outlets for fire service use).

Vertical series staging of fire pumps creates unacceptable reliability concerns.

In vertical series staging, the first (lowest) pump discharges to the first-zone sprinklers and the suction of the second pump; the second pump discharges to the second-zone sprinklers and the suction of the third pump; etc. If fire occurred near the top of a building having three vertical zones, it would be necessary for the first pump to start, then the second, then the third. Any one of the three pumps failing to start would prevent water from being supplied to the upper floor sprinklers.

With an approximately 3% failure-to-start rate for electric-motor-driven units, the reliability for the third zone is reduced from 97% to 91%. Almost one in eleven times, there is no water available in the third zone.

3.1.3 Pump Suction and Discharge Piping

Where the fire pump suction supply is from a factory-use water system, it is desirable to verify that pump operation at 150% of rated capacity does not create hazardous process upsets due to low water pressure.

Turbulent flow created by components located upstream from the pump suction inlet should be minimized to prevent degradation of the pump performance. The distance of 10 pipe diameters is a general guideline that has been used by the water control industry. This distance is considered to be adequate only if all flow and pressure criteria for pump acceptance are met.

Suction Piping

A butterfly valve on the suction side of the pump can create turbulence adversely affecting the pump performance and can increase the possibility of pipe blockage. In addition, the disc in a butterfly valve decreases the flow area in the valve body and necessarily provides an increased head loss compared with a gate valve of equal size. The disc inherently causes turbulence. For these reasons, do not install a butterfly valve in the pump suction piping.

Check valves and backflow prevention devices and assemblies are tolerable where required by the authority having jurisdiction.

Suction Screening and Sump Construction

When selecting screen material, consider the prevention of fouling from aquatic growth. This is best accomplished with brass or copper wire.

A sound suction screen will be constructed of brass, copper, monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of ½-in. (12.7 mm) mesh and No. 10 gauge wire to a metal frame sliding vertically at the entrance to the intake. The overall area of this screen should be approximately 1.6 times the net screen opening area.

Figures 9 through 12 illustrate dimensions recommended by the Hydraulics Institute Standards for intake design using a sump (wet pit).

The dimension variables are as follow:

S — This is the minimum width of the wet pit.
B — This is the suggested maximum dimension of the pump centerline from the back wall. The edge of the bell should be close to the back wall.
C — Should be specified by the pump manufacturer.
H — This is the minimum value based on minimum water level. Submergence for determining the location of the second impeller from the bottom of the pump bowl assembly is H minus C.
Y — This is the minimum recommended distance of the pump centerline to the screen.

Based on expected maximum pump flow, recommended values are as follows:

Table 4. Minimum Sump Dimensions

Pump flow, gpm (L/min)	S, in. (mm)	B, in. (mm)	Y, in. (mm)
Up to 3000 (11,400)	34 (864)	13 (330)	60 (1524)
4,000	40 (1016)	16 (406)	70 (1778)
5,000	44 (1118)	18 (457)	75 (1905)

Note that other values may be used when recommended by the pump manufacturer or when alternate designed are certified as being in accordance with the design principles in the Hydraulic Institute Standards.

When determining dimension S in order to not exceed 1 ft/s (0.7 m/s) velocity in the wet pit, dimension H will be fixed, and S should be either the minimum indicated above, or larger if needed to not exceed the velocity limits.

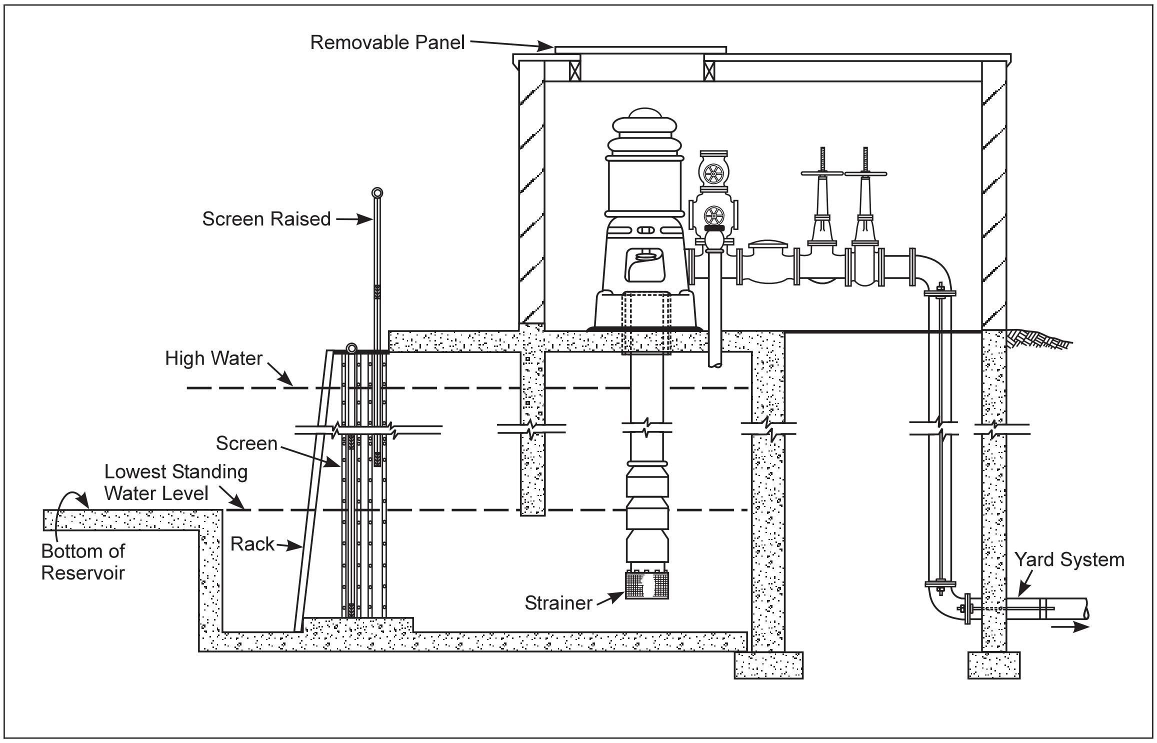
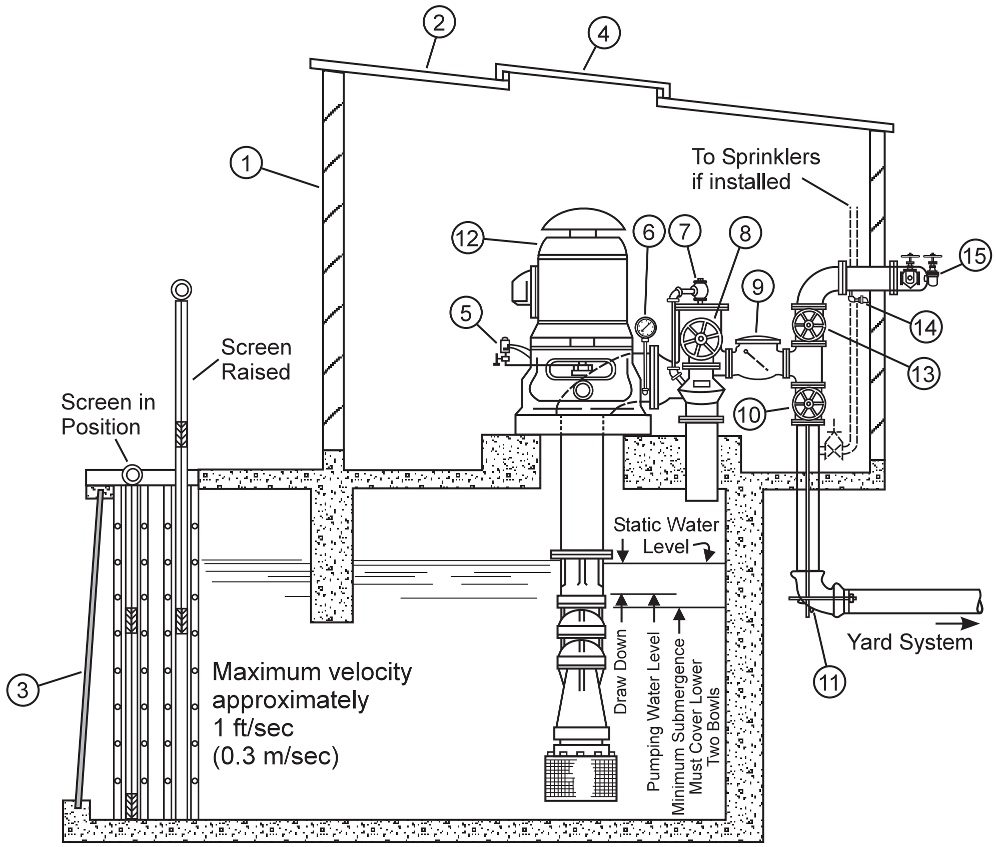


Fig. 9. Vertical shaft turbine-type pump installation in a wet pit



1. Suggested size of pump room for one pump 12 by 16 by 10 ft (3.7 by 4.9 by 3.0 m) high. Larger rooms for multiple-pump installations. Walls of noncombustible construction: brick, tile, concrete, or corrugated asbestos on steel frame (last suitable only where climate makes heating unnecessary). Floor of concrete.
2. Noncombustible roof; otherwise install sprinklers.
3. Trash rack, 1/2-in. flat or 3/4-in. round steel bars spaced 2 to 3 in. apart.
4. Roof hatch
5. Solenoid oil valve; oils line-shaft bearings, when required
6. Discharge gage
7. Automatic air release
8. Pressure-relief valve, waste cone, and waste pipe, when required
9. Discharge check valve
10. Discharge valve
11. Discharge pipe
12. Vertical hollow-shaft electric motor or approved right-angle gear
13. Hose-connection valve
14. Ball drip, when required
15. Approved flow meter or hose header and hose valves

Fig. 10. Vertical-shaft turbine-type fire pump installation with suction from wet pit

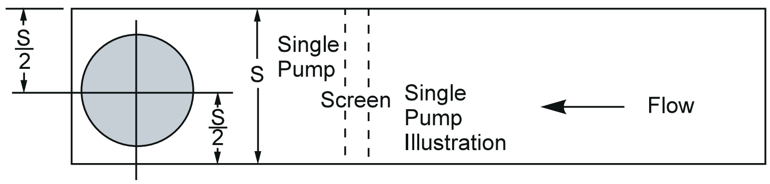


Fig. 11. Sump dimensions plan view

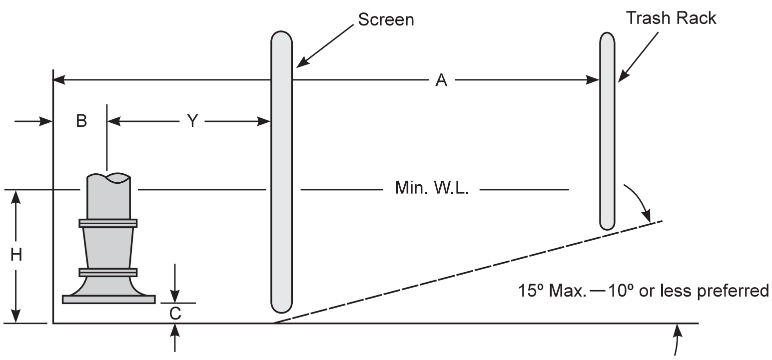


Fig. 12. Sump dimensions elevation view

3.1.4 Split Case, End Suction, and In-Line Centrifugal Pumps

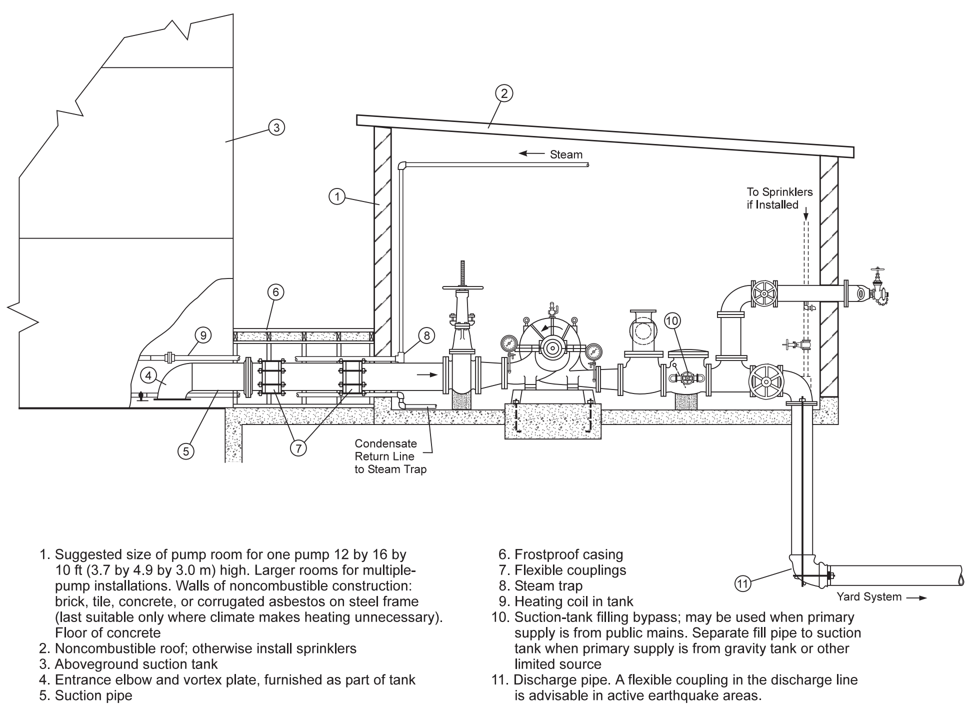
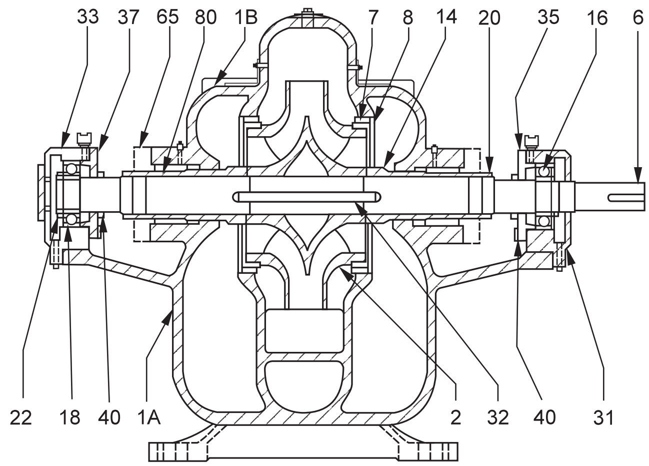
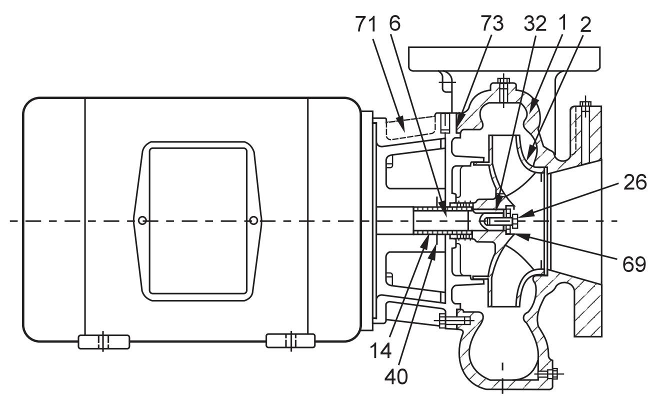


Fig. 13. Typical horizontal-shaft fire pump installation with suction from aboveground tank



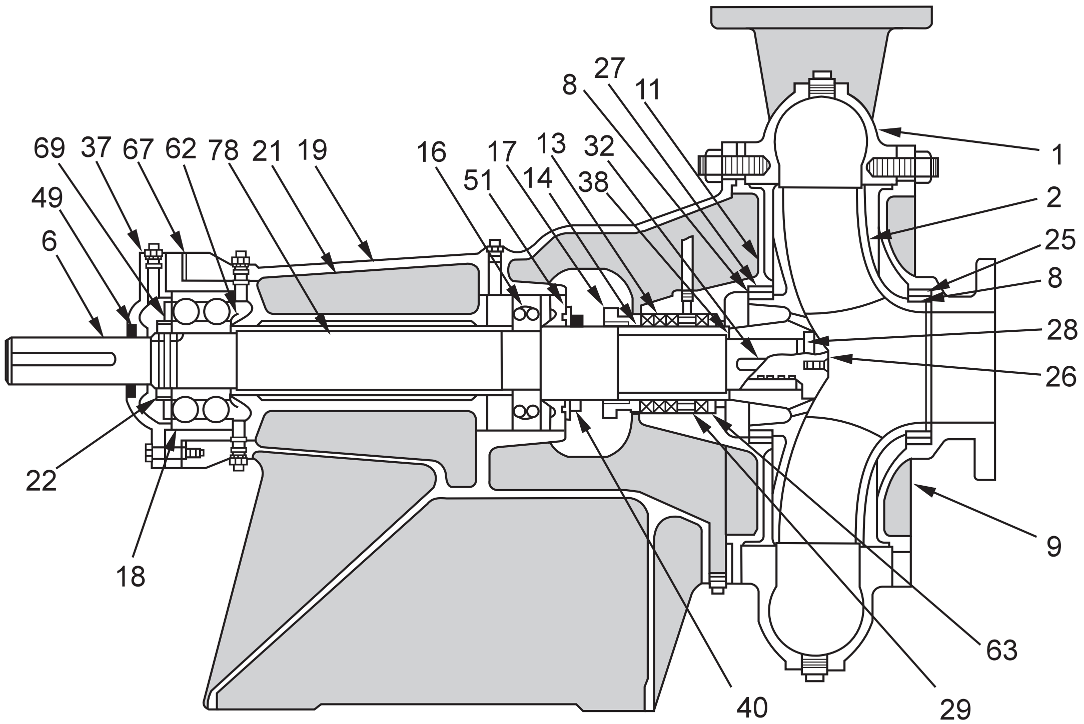
1A Casing, lower half
1B Casing, upper half
2 Impeller
6 Shaft
7 Ring, casing
8 Ring, impeller
14 Sleeve, shaft
16 Bearing, inboard
18 Bearing, outboard
20 Nut, shaft sleeve
22 Locknut
31 Housing, bearing inboard
32 Key, impeller
33 Housing, bearing outboard
35 Cover, bearing inboard
37 Cover, bearing outboard
40 Deflector
65 Seal, mechanical stationary element
80 Seal, mechanical rotating element

Fig. 14. Cutaway drawing of a typical horizontal shaft split case pump
(Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)



1 Casing
2 Impeller
6 Shaft, pump
14 Sleeve, shaft
26 Screw, impeller
32 Key, impeller
40 Deflector
69 Lockwasher
71 Adapter
73 Gasket

Fig. 15. Cutaway drawing of a typical end suction pump with a close coupled electric motor
(Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)



1 Casing
2 Impeller
6 Shaft, pump
8 Ring, impeller
9 Cover, suction
11 Cover, stuffing-box
13 Packing
14 Sleeve, shaft
16 Bearing, inboard
17 Gland
18 Bearing, outboard
19 Frame
21 Liner, frame
22 Locknut, bearing
25 Ring, suction cover
26 Screw, impeller
27 Ring, stuffing-box cover
28 Gasket
29 Ring, lantern
32 Key, impeller
37 Cover, bearing, outboard
38 Gasket, shaft sleeve
40 Deflector
49 Seal, bearing cover, outboard
51 Retainer, grease
62 Thrower (oil or grease)
63 Bushing, stuffing-box
67 Shim, frame liner
69 Lockwasher
78 Spacer, bearing

Fig. 16. Cutaway drawing of a typical separately coupled end suction pump
(Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)

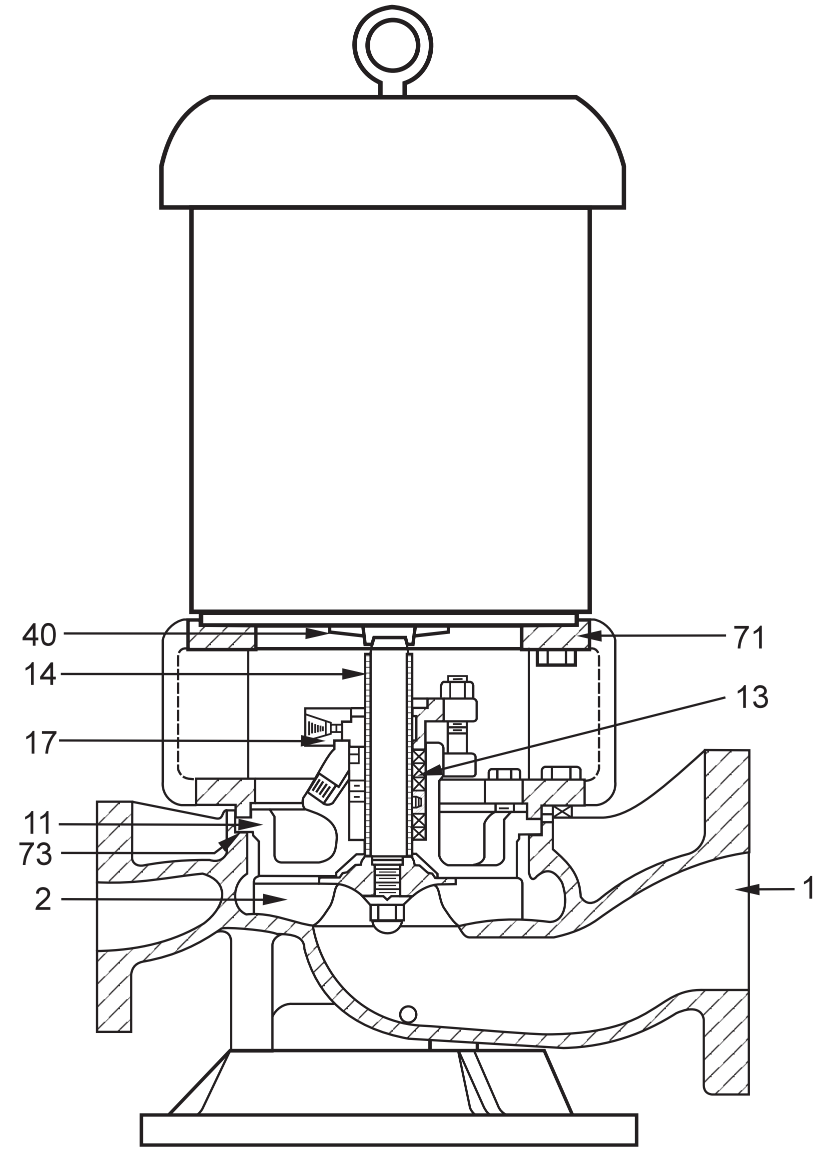
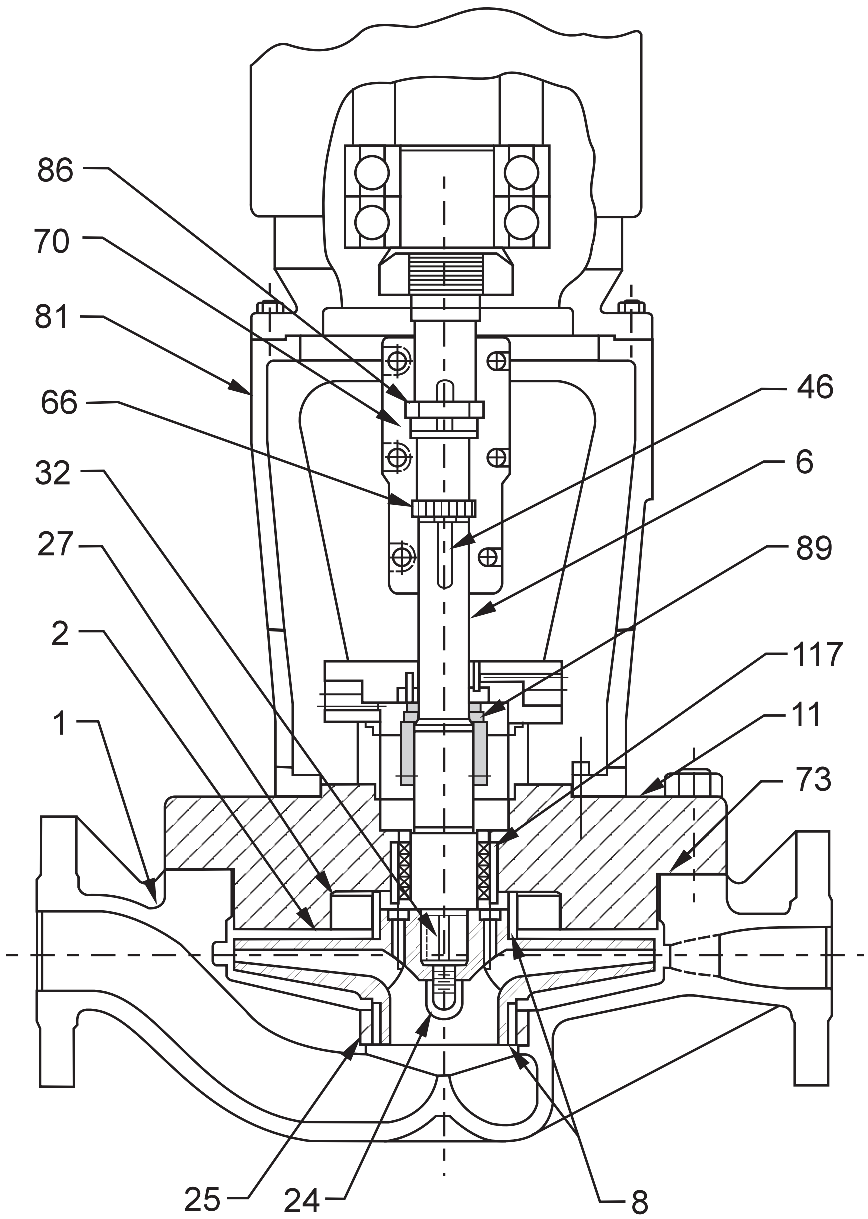


Fig. 17. Cutaway drawing of a typical vertical in-line pump with a close coupled electric motor (Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)



1 Casing
2 Impeller
6 Shaft, pump
7 Ring, casing
8 Ring, impeller
11 Cover, seal chamber
24 Nut, impeller
27 Ring, stuffing-box cover
32 Key, impeller
46 Key, coupling
66 Nut, shaft adjusting
70 Coupling, shaft
73 Gasket
81 Pedestal, driver
86 Ring, thrust, split
89 Seal
117 Bushing, pressure reducing

Fig. 18. A more detailed cutaway drawing of a typical separately coupled vertical in-line pump (Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)

Limited-Service Pumps

Limited-service fire pumps furnish not less than 130% of rated capacity at not less than 65% of rated head. They are limited to a maximum of 30 hp across-the-line starting electric motor drive only.

3.1.5 Vertical Shaft Turbine-Type Pumps

The vertical shaft turbine-type pump is particularly suitable for fire pump service when the source of water is located below ground and where it would be difficult to install any other type of pump below the minimum water level. It was originally designed for installation in drilled wells, but is equally suitable to be used to lift water from lakes, streams, open reservoirs, and other subsurface sources like underground tanks. Both oil-lubricated enclosed-lineshaft and water-lubricated open-line-shaft pumps are used. (See Figure 19)

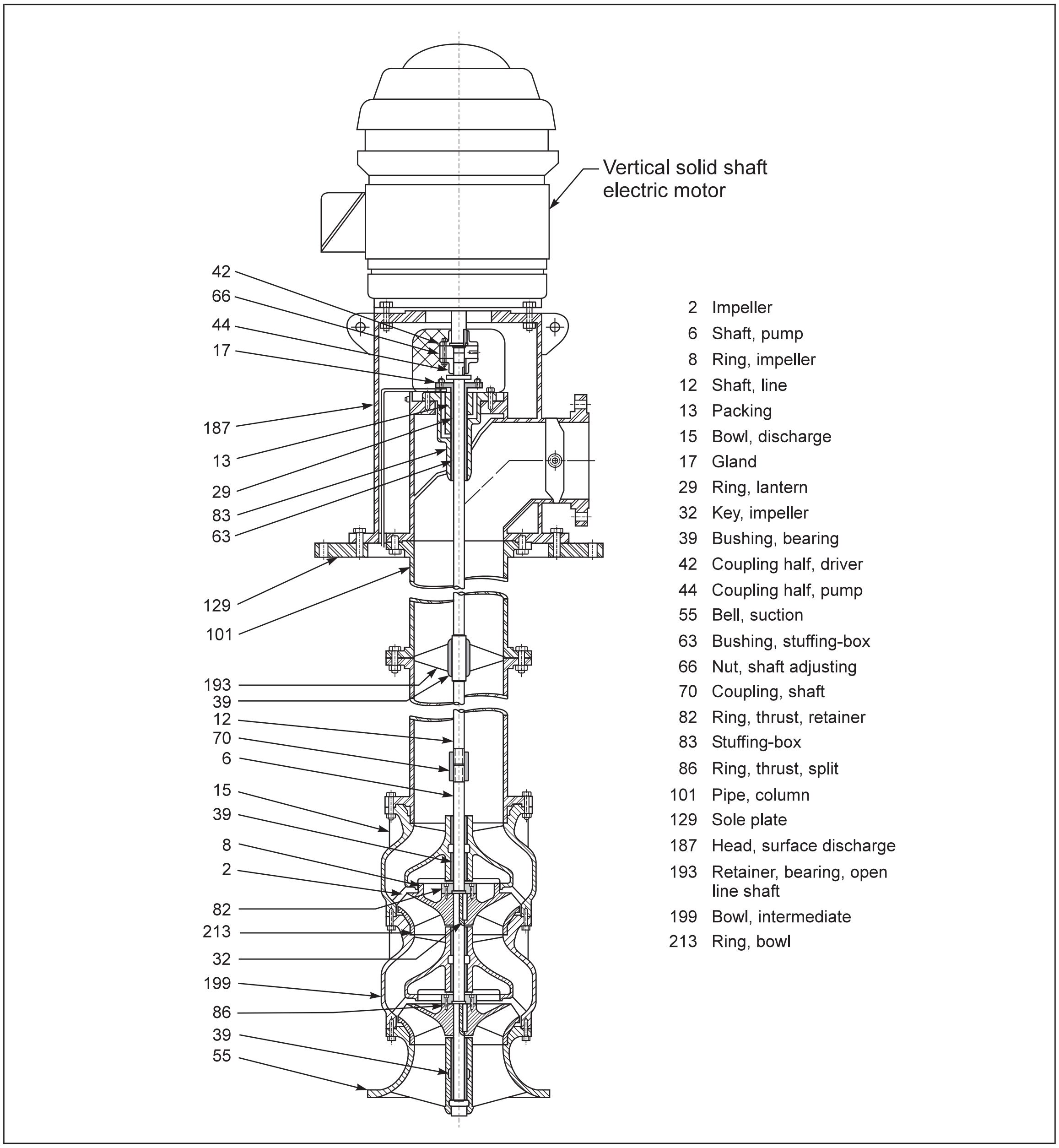


Fig. 19. A cutaway drawing of a typical two stage vertical turbine pump
(Provided courtesy of the Hydraulics Institute, Parsippany, NJ www.pumps.org)

This type of pump is particularly adaptable for installation on open bodies of water subject to variation of surface water levels.

The use of these pumps is also recommended where an automatically controlled pump is desired and the physical conditions are such that a horizontal-shaft pump would have to take suction under lift.

Since vertical-shaft turbine-type pumps do not require priming, their use under this condition eliminates the need for complicated automatic priming equipment.

The use of deep wells for direct fire pump service is undesirable if the maximum length of column pipe-and-bowl assembly would exceed 100 to 150 ft (30 to 45 m). Breakdown is more likely to occur with long shafts, and repairs would take more time. To meet the required ground-level pressure, the head rating of the pump would have to be increased; likewise, this would increase the size of the driver. Deep wells and long pump shafts usually increase significantly the total cost of the installation. Under these conditions, it may be more economical and reliable to provide aboveground storage tanks or reservoirs from which horizontal fire pumps could take suction. Deep well pumps of relatively low head and small capacity could be used for filling.

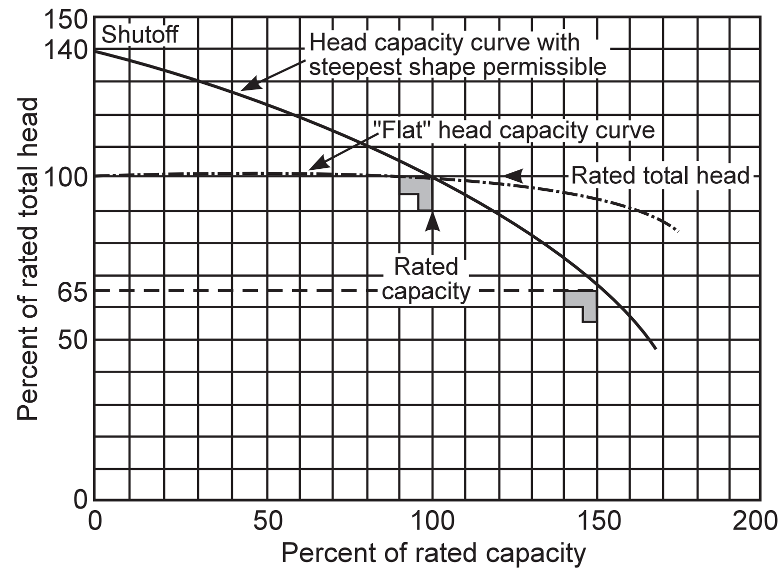


Fig. 20. Pump characteristics curves

Listed pumps can have different head capacity curve shapes for a given rating. Figure 20 illustrates the extremes of the curve shapes probable. Shutoff head will range from minimum of 101% to maximum of 140% of rated head. At 150% of rated capacity, head will range from a minimum of 65% to maximum of just below rated head. Pump manufacturers can supply expected curves for their listed pumps.

Turbulent flow created by components located upstream from the pump suction inlet should be minimized so pump performance is not compromised. The distance of 10 pipe diameters is considered by the water control industry as an acceptable distance.

3.1.6 Positive Displacement Pumps

Unlike centrifugal pumps, positive displacement pumps are capable of exceeding their maximum design discharge pressure if pumped against a closed piped system. The relief valve ensures the system is not over-pressurized. The unloader valve is needed to ensure that pump driver can achieve rated speed before being subjected to the pump load. This is particularly true of diesel-driven positive displacement pumps where the near instantaneous high torque requirement of a positive displacement pump can stall the engine starter motor.

3.1.7 Mounting, Coupling, and Alignment

A substantial foundation is important in maintaining alignment. The preferable foundation construction material is reinforced concrete.

All base plates are flexible to some extent and, therefore, must not be relied upon to maintain the factory alignment. Realignment is necessary after the pump and driver have been leveled on the foundation and again after the grout has set and foundation bolts have been tightened. Check the alignment after the piping connections to the pump and driver are made, and recheck the alignment annually.

After the pump and driver have been placed on the foundation, disconnect the coupling halves. Keep the coupling disconnected until all the shaft alignment operations have been completed. The purpose of the flexible coupling is to compensate for temperature changes and to permit end movement of the shafts without interference with each other while transmitting power from the driver to the pump.

There are two forms of misalignment between the pump shaft and the driver shaft, as follows:

a. Angular misalignment: shafts with axes concentric but not parallel.

b. Parallel misalignment: shafts with axes parallel but not concentric.

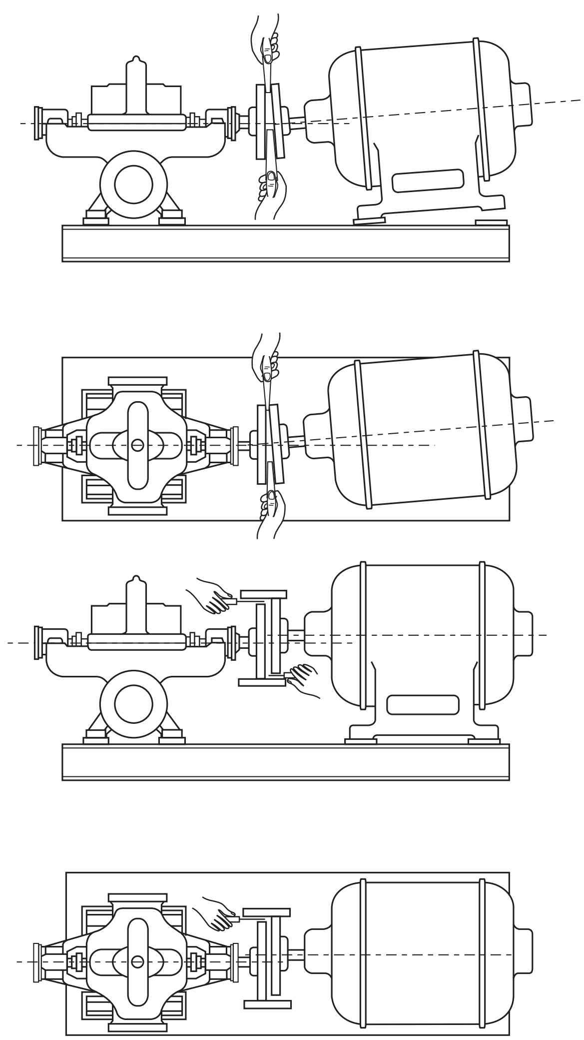


Fig. 21. Checking angular and parallel alignment
(Provided courtesy of the Hydraulics institute, Parsippany, NJ www.pumps.org)

Space the faces of the coupling halves within the manufacturer's recommended limits. Make an allowance for wear of the thrust bearings that will cause the pump shaft to move in the axial direction. The necessary tools for an approximate check of the alignment of flexible coupling are a straight edge and taper gage or set of feeler gages.

A check for angular alignment is made by inserting the taper gage or feelers at four points between the coupling faces and comparing the distance between the faces at four points spaced at 90-degree intervals around the coupling. The pump and driver shafts will be in angular alignment when the measurements show the coupling faces are the same distance apart at all points.

A check for parallel alignment is made by placing a straight edge across both coupling rims at the top, bottom, and at both sides. The pump and driver shafts will be in parallel alignment when the straight edge rests evenly on the coupling rim at all positions. Allowance may be necessary for temperature changes and for coupling halves that are not of the same outside diameter. Care must be taken to have the straight edge parallel to the axes of the shafts.

When the alignment is correct, the foundation bolts should be tightened evenly, but not too firmly. The base plate can then be grouted to the foundation. The base plate can be completely filled with grout, and it is desirable to grout the leveling pieces, shims or wedges in place. Foundation bolts cannot be fully tightened until the grout is hardened, usually about 48 hours after pouring. After the grout has set and the foundation bolts have been properly tightened, check the pump and driver for parallel and angular alignment and, if necessary, take corrective measures. After the piping has been connected to the pump and driver, check the alignment once more.

At this time, the direction of driver rotation can be verified to make certain it matches that of the pump. The corresponding direction of rotation of the pump is indicated by a direction arrow on the pump casing.

The coupling halves can then be reconnected. With the pump properly primed, the pump can be operated under normal operating conditions until temperatures have stabilized. Following engine shut down, immediately check for alignment of the coupling. All alignment checks must be made with the coupling halves disconnected and again after they are reconnected.

After the pump has been in operation for about 10 hours, the coupling halves should be given final check for misalignment caused by pipe or temperature strains. If the alignment is correct, both pump and driver should be doweled to the base plate. Dowel installation and location is very important, especially if the equipment is subjected to temperature changes. Obtain the recommended locations from the manufacturer.

If the pump does not stay aligned after being properly installed, the following are possible causes:

a. Settling, seasoning or springing of the foundation

b. Pipe stress distorting or shifting the pump

c. Wear of the bearings

d. Springing of the base plate due to temperature

e. Shifting of the building structure due to variable loading or other causes

It may be necessary to slightly readjust the alignment from time to time while the pump and foundation are new.

3.1.8 Mechanical Seals

Mechanical shaft seals are an alternative to traditional soft packing around the shaft as it exits the pump body. Mechanical seals have the advantage of not normally leaking water around the pump shaft. Soft packing has the advantage of being readily available and easily replaceable.

Mechanical pump seal designs can be vulnerable to total seal failure due to damage from water supply contaminates or adhesion of the seal faces due to long periods of inactivity. The total loss of the seal will incapacitate the pumping ability of the pump. Replacement mechanical seals can be difficult to source and require dismantling the pump. Therefore, check water quality and verify regular testing can be accomplished before a mechanical seal is selected for use in a particular application. (See Fig. 22)

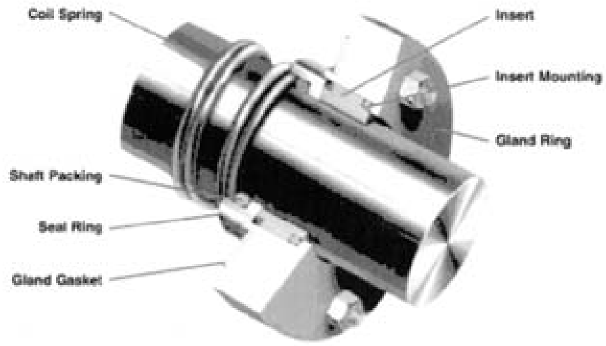


Fig. 22. Mechanical Pump Seal

3.1.9 Pump Sizing

The capacity and pressure of a fire pump can be determined for each individual fire protection system only after due consideration of all the factors involved. For determining approximate pump flow and pressure requirements, refer to the appropriate FM Global occupancy data sheet listed in Section 4.1.

Where pumps are to supply automatic sprinklers and/or hose streams/hydrants, refer to FM Global Data Sheets 2-0, *Installation Guidelines for Automatic Sprinklers*, 4-4N, *Standpipe and Hose Systems,* and any relevant occupancy data sheet that addresses water demands.

The maximum required pressure used in the design of a fire protection system supplied by a fire pump is the pump rated pressure plus suction pressure at rated flow. In Figure 23, Curve A represents the theoretical characteristic curve for a 1500 gpm, 75 psi rated horizontal fire pump taking suction from the source shown by E. Curve B is more typical of actual pump performance. Many pumps will not provide 140% of rated pressure at shutoff (churn).

1 gpm = 3.8 L/min
1 psi = 6.9 kPa = .069 bar

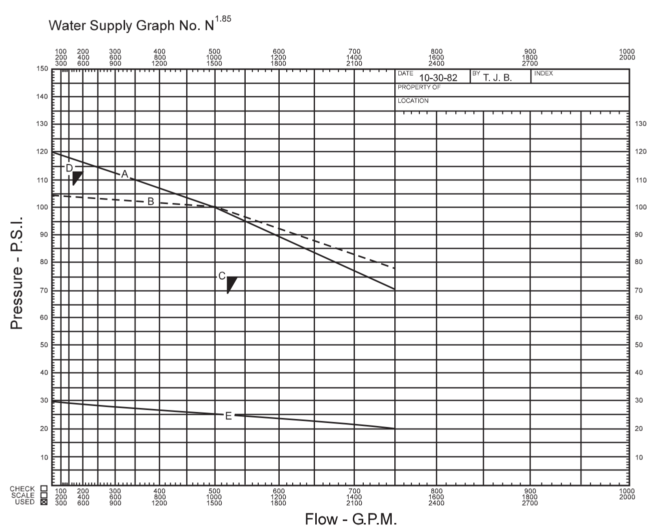


Fig. 23. Water supply graph

Demand point C represents a high-volume, moderate-pressure system. The demand can be supplied by the pump.

Demand point D represents a low-volume, high-pressure system. The actual pump performance cannot meet the demand.

3.1.10 Pressure Relief Valves

The use of most pressure relief valves can be avoided by using proper system design techniques to ensure the system will not experience excess pressure.

A good design will ensure that pump shutoff (churn) pressure plus static suction pressure does not exceed the maximum pressure rating for system components, which is usually 175 psi (11.9 bar). For fire pumps taking suction from tanks or wet pits, such designs are easily achievable.

For booster fire pumps taking suction from public water supplies, such designs are achievable in most cases by the proper sprinkler system pipe sizing to minimize friction loss, and the selection of a pump with a characteristic curve that most closely matches the system design requirements without causing excessive pressure under churn conditions. Designs that intentionally incorporate the use of smaller pipe and the use of a relief valve to truncate a portion of the water supply curve downstream from the fire pump are to be avoided.

Under certain circumstances, where static suction pressures for booster pumps vary, good fire protection system design practice would dictate that the pump discharge characteristics be selected on the basis of the lowest expected static suction pressure so as not to compromise the adequacy of the overall system hydraulic design. In those cases, it may be possible that the pump operating in the higher range of expected static suction pressures may produce discharge pressures in excess of the maximum pressure ratings for the system components, necessitating the use of a pressure relief valve. In such cases, when it is necessary to install a pressure relief valve, it is advisable to use a pilot-operated type pressure relief valve, with the pilot sensing line connected on the fire pump discharge line downstream from the discharge check valve.

For diesel-driven pumps, the pressure is required to be elevated at 121% of the net rated shutoff pressure because the pressure is proportional to the square of the speed that the pump is turned. A diesel engine governor is required to be capable of limiting the maximum engine speed to 110%, creating a pressure of 121%.

3.1.11 Variable Speed Pumps

Variable speed pumps add an additional level of system complexity and testing and maintenance burdens that are best avoided if possible. They can be a good tool for dealing with a system that has excess pressure if other options have been eliminated.

Typical applications where a variable speed pump might be suitable:

(1) A water supply with a wide range of suction pressure variation

(2) Reducing the number or eliminating the need for pressure reducing valves in high-rise buildings

(3) Suppression mode systems in tall buildings with high end-head pressure requirements.

3.1.12 Pump Starting and Control

Where the pump supplies special water control equipment (e.g., deluge valves, dry-pipe valves, etc.), it is advisable to arrange the pump to start before the pressure-actuated switch(es) would do so. Under such conditions, the controller should be configured to start the pump upon operation of the fire protection equipment. This will lessen the possibility of a water hammer condition.

The intent of manual stopping is that whenever the pumps starts, the pump house is visited by appropriate personnel to ensure the pump unit is running properly, and to make sure the pump is not stopped until it is ascertained that pump-starting causes have returned to normal and any fire emergency has been successfully resolved.

Manual stopping only will ensure the pump remains on during fire fighting efforts. A pump that cycles on and off can pose a problem for fire fighters using hose lines supplied by the pump.

A fire pump must not be used to maintain pressure in the fire protection system. This is the function of the pressure maintenance (jockey) pump. However, it must start as soon as a dry pipe, pre-action, or deluge system has tripped, or one or more sprinklers on a wet pipe system have operated. Large differences in pressure between the pump starting pressure and the pump discharge pressure can result in damaging water hammer. Where there is more than one pump, coordinate the starting of each pump so they do not start simultaneously, but do start promptly. The simultaneous starting of pumps can exacerbate a water hammer problem. Also, in the case of two electric motor driven pumps, simultaneous starting can increase the possibility of tripping an upstream overcurrent device in the electrical feed.

Installation of the pressure-sensing line between the discharge check valve and the control valve is necessary to facilitate isolation of the jockey pump controller (and sensing line) for maintenance without having to drain the entire system.

3.1.13 Electric Motor-Driven Pumps

Power Supply Arrangement

A reliable electrical feed is one that is:

1. Not exposed to direct damage from fire/explosions, or from any equipment or other processes that are part of the plant's normal operations,

2. Not exposed to electrical/mechanical problems created by non-fire protection equipment connected to the same feed (note that electrical/mechanical problems for the fire protection equipment itself is already covered by the various requirements in the relevant Approval Standards), and

3. Arranged so that disconnection will not be made during fire event by plant staff, fire department, or others.

Feeder Overcurrent Protection

Separate overcurrent protection is not required for the fire pump feeder. Experience shows that short circuits are unlikely to occur in a properly arranged fire pump feeder, and omitting such protection will eliminate another possible source of trouble that may interrupt the power supply to the fire pump. If a short circuit does occur, protective devices farther back on the utility system will clear it.

Limited-Service Controllers

Limited service controllers are intended as a lower-cost alternative to electric fire pump controllers for small pumps. The primary differences are the use of a less expensive thermo-magnetic circuit breaker and the lack of an isolating switch that necessitates the need for an upstream disconnect switch and/or an overcurrent protection device (fuses or a circuit breaker). The thermo-magnetic breaker trip point is affected by its ambient temperature and it retains a thermal “memory” after each trip that requires it to cool before its trip point is restored to its original threshold.

Variable Speed Electric Pumps

Variable-speed, electric motor-driven pumps use a variable frequency drive within the fire pump controller to reduce the incoming power line frequency (60 or 50 Hz) in order to slow the speed of the motor if the set pressure limit is exceeded. The pressure-limit adjustment means is located in the fire pump controller cabinet. The controller is designed to bypass the variable frequency drive and provide a direct connection to line power automatically in the event of a problem, or manually via a switch on the controller exterior.

3.1.14 Diesel Engine-Driven Pumps

Fuel Tank and Piping

It is recommended that diesel fuel storage tanks are located inside the pump room or pump house with fill and vent lines extended outdoors, if permitted by local regulations. This maximizes the reliability of the fuel transfer and ensures the fuel storage tank does not experience freezing temperatures. The fill pipe may be used for a gauging well, where practical.

Engine Cooling

Open-Loop Heat Exchanger-Cooled Engines

The maximum pressure allowable on the diesel engine cooling line should be indicated on the pressure gauge. When the pressure regulator is bypassed, the pressure cannot exceed the maximum rated pressure of the components and piping or a failure of the cooling system and, consequently, the diesel engine can occur. Heat-exchanger-cooled engines are equipped with an engine-driven coolant pump that circulates coolant around the heat exchanger tubes and through the engine block. Use only new coolant complying with the engine manufacturer's recommendation and distilled water in the circulating system. The coolant temperature is regulated by a thermostat in the circulating system.

Raw water for the heat exchanger is piped from the fire pump through connection between the pump outlet and the discharge valve. The raw-water line is equipped with strainer, control valves, bypass, and gauge connection. When the heat-exchanger tubes are not designed to withstand 300 psi(2067 kPa, 20.7 bar), a regulator is provided in the raw-water line. When the pump is arranged for automatic starting, the raw-water line is equipped with a normally closed solenoid valve that opens only when the engine is running; otherwise, water from the suction tank or reservoir could be wasted through the pump and engine-cooling system. A solenoid valve is not required when the pump is a vertical-shaft turbine-type installed in a well or wet pit. Engine-exhaust manifolds that are cooled with water have water jackets connected into the circulating cooling system or into the raw-water discharge line from the heat exchanger. Oil coolers, intake manifolds, and other parts may also be equipped with water jackets supplied from the cooling system, as recommended by the engine manufacturer. Engines require a flow of 15 to 65 gpm (56.8 to 246 L/m), or more, of raw water through the heat exchanger for adequate cooling. To allow for quick inspection of proper engine cooling, the raw-water outlet should discharge freely to atmosphere in a location visible to the operator, usually the waste cone of the pump relief valve.

Radiator-Cooled Engines

Radiator-cooled engines require much more cooling air than comparably rated heat exchanger cooled engines.

A thermostatically controlled bypass may be used to obtain warm air from the discharge air duct to reduce the pump room heating load during engine operation. Duct air obtained from bypass in a manner to prevent it from circulating directly back to the radiator.

Variable-Speed Diesel Pumps

FM Approved variable-speed diesel pumps use a pressure connection to the discharge of the valve that directly reduces the speed of the engine if the set pressure limit is exceeded. The pressure-limiting control and the pressure-limit-adjustment means is located on the engine and is independent of the fire pump controller. The variable speed control can be by-passed by closing the valve on the pressure connection piping that runs between the pump discharge and the pressure control on the engine.

4.0 REFERENCES

4.1 FM Global

Installation Data Sheets

Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers.*
Data Sheet 3-2, *Water Tanks for Fire Protection.*
Data Sheet 3-10, *Installation and Maintenance of Private Fire Service Mains and Their Appurtenances.*
Data Sheet 4-4N, *Standpipe and Hose Systems.*

Occupancy Data Sheets

The following list contains FM Global data sheets that may be helpful in determining the sprinkler system water demand requirements for the specific hazards or occupancies listed.

Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 1-56, *Cleanrooms*
Data Sheet 3-26, *Fire Protection Water Demand for Nonstorage Sprinklered Properties*
Data Sheet 4-7N, *Low Expansion Foam Systems*
Data Sheet 5-14, *Telecommunications*
Data Sheet 7-1, *Fire Protection for Textile Mills*
Data Sheet 7-7/17-12, *Semiconductor Fabrication Facilities*
Data Sheet 7-10, *Wood Processing and Woodworking Facilities*
Data Sheet 7-11, *Conveyors*

Data Sheet 7-14, *Fire Protection for Chemical Plants*
Data Sheet 7-27, *Spray Application of Flammable and Combustible Materials*
Data Sheet 7-32, *Ignitable Liquid Operations*
Data Sheet 7-41, *Heat Treating of Materials Using Oil Quenching and Molten Salt Baths*
Data Sheet 7-64/13-28, *Aluminum Industry*
Data Sheet 7-80, *Organic Peroxides*
Data Sheet 7-83, *Drainage Systems for Ignitable Liquids*
Data Sheet 7-89, *Ammonium Nitrate and Mixed Fertilizers Containing Ammonium Nitrate*
Data Sheet 7-91, *Hydrogen*
Data Sheet 7-93N, *Aircraft Hangars*
Data Sheet 7-98, *Hydraulic Fluids*
Data Sheet 7-99, *Heat Transfer by Organic and Synthetic Fluids*
Data Sheet 7-101, *Fire Protection for Steam Turbines and Electric Generators*
Data Sheet 8-3, *Rubber Tire Storage*
Data Sheet 8-7, *Baled Fiber Storage*
Data Sheet 8-9, *Storage of Class 1, 2, 3, 4 and Plastic Commodities*
Data Sheet 8-10, *Coal and Charcoal Storage*
Data Sheet 8-18, *Storage of Hanging Garments*
Data Sheet 8-21, *Roll Paper Storage*
Data Sheet 8-22, *Storage of Baled Waste Paper*
Data Sheet 8-23, *Rolled Nonwoven Fabric Storage*

FM Approval Standards

1311, *Centrifugal Fire Pumps (Horizontal Split-Case Type)*
1312, *Centrifugal Fire Pumps (Vertical Shaft, Turbine Type)*
1319, *Centrifugal Fire Pumps (Horizontal, End Suction Type)*
1321/1323, *Controllers for Electric Motor Driven and Diesel Engine Driven Fire Pumps*
1333, *Diesel Engine Fire Pump Drivers*
1338, *Right Angle Gear Drives*
1361, *Water Pressure Relief Valves*
1371, *Centrifugal Fire Pumps (In-Line Type)*

Publications

“Pocket Guide to Inspecting, Testing and Maintaining Fire Protection Equipment” (P0418)
“Fire Pump Testing and Maintenance Checklist”, (P8217)

4.2 NFPA Standards

Material in this data sheet is covered in part by several NFPA standards; in particular, NFPA 20, Stationary Pumps for Fire Protection. Generally, FM Global guidelines agree with those of NFPA 20.

NFPA 20, *Stationary Pumps for Fire Protection,* 2007 edition
NFPA 70, *National Electrical Code,* 2008 edition

National Fire Protection Association, Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

4.3 Other Standards

British Standards Institute (BSI). *Fixed Firefighting Systems: Automatic Sprinkler Systems Design, Installation and Maintenance.* EN 12845:2004.

VdS Schadenverhutung GmbH. *VdS CEA Guidelines for Sprinkler Systems: Planning and Installation.* VdS CEA 4001: 2005-09.

Hydraulic Institute (HI). *Various standards for centrifugal, rotary, and reciprocating pumps.* 2005 editions.

National Electrical Manufacturers Association (NEMA). *Motors and Generators.* NEMA MG 1: 2006.

National Electrical Manufacturers Association (NEMA). *Application Guide for Electric Fire Pump Controllers.* NEMA ICS 14:2004.

National Electrical Manufacturers Association (NEMA). *Instructions for the Handling, Installation, Operation, and Maintenance of Electric Fire Pump Controllers Rated Not More than 600 V.* NEMA ICS 15:2004.

APPENDIX A GLOSSARY OF TERMS

Automatic control: Control of an operation without human intervention.

Automatic transfer switch (ATS): Self-acting equipment for transferring electrical power load conductor connections from one power source to another.

Branch circuit: The circuit conductors between the final overcurrent device protecting the circuit and the utilization equipment.

Break tank: A fire protection water tank that is not sufficient in size for the full fire protection demand utilizes automatic replenishment to achieve adequacy.

Cavitation: A reduction of pressure within a pump that causes water vaporization. Cavitation reduces a pump's performance and can damage the pump impeller.

Circulation relief valve: A valve on a fire pump designed to discharge a small amount of water to prevent overheating of the pump during shutoff conditions.

Diesel engine: An internal combustion engine in which the fuel is ignited entirely by the heat resulting from the compression of the air supplied for combustion.

Diesel engine fire pump controller: Fire pump controller intended to control a diesel engine-driven fire pump.

Driver: The electric motor or diesel engine that drives the fire pump.

Electric fire pump controller: Fire pump controller intended to control an electric motor-driven fire pump.

Feeder (fire pump): The conductors between the transformer and the fire pump controller.

Fire pump: A pump dedicated to deliver a specified rate of water flow at a specified pressure to a fire protection system.

Fire pump controller: An enclosed group of devices that serve to govern, in a predetermined manner, the starting and stopping of the fire pump driver, as well as monitor and signal the status and condition of the fire pump package.

Fire pump package: An assembled unit consisting of a fire pump, driver, controller, and accessories.

Flexible coupling: A device used to connect a driver to a pump; it can compensate for small misalignments and dampen vibration.

Foam pump controller: Special electric or diesel engine fire pump controllers intended for the unique requirements of foam concentrate fire protection pumps.

Full voltage or reduced voltage starting: Electric motor controllers may be configured for direct on-line starting (full voltage) or for reduced motor starting current (reduced voltage).

High-Rise Building: A building more than 75 ft (23 m) in height.

Mass elastic torsional analysis: An engineering analysis conducted for the purpose of identifying and eliminating damaging torsional forces and linear resonant frequencies from the operating speed range of rotating equipment.

Maximum working pressure: The highest pressure developed at the pump discharge flange under any anticipated condition of suction pressure and pump flow.

Mechanical seals: A sealing device that forms a seal between the pump shaft and stationary components. If may be used in place of compression (soft) packing. The primary seal is achieved by two very flat, lapped faces perpendicular to the shaft The rubbing contact between these two flat mating surfaces minimizes leakage. One face is held stationary in a housing and the other face is fixed to, and rotates with, the shaft Dissimilar materials are usually used for the stationary insert and the rotating seal ring face in order to prevent adhesion of the two faces.

Multiple stage pumps: Horizontal split-case, centrifugal fire pumps with more than one impeller on the same shaft The number of stages is determined by the number of impellers.

Net positive suction head (NPSH) required: The minimum pump suction pressure needed to prevent vaporization of the water (cavitation) in the pump.

Pressure reducing valve: A valve in a fire protection system that is designed to limit down-stream water pressure under both flowing and non-flowing (static) conditions.

Rated pump capacity: Flow capacity (gal/min [L/min]), at rated pressure and speed.

Rated pressure: Pressure in pounds per square inch — psi (kilopascals -kPa) developed by the pump when operating at rated capacity.

Relief valve (main): A valve near the discharge of a fire pump used to limit the pressure in the fire protection system under abnormal conditions.

Service factor: A multiplier that, when applied to the rated horsepower of an ac motor, indicates a permissible horsepower loading that can be carried at the rated voltage, frequency, and temperature. The service factor multiplier (e.g., 1.15) indicates that the motor is permitted to be overloaded 1.15 times the rated horsepower without insulation breakdown or otherwise significantly reducing service life.

Shutoff or churn pressure: The net pressure in psi (kPa) developed by the pump at rated speed with zero flow.

Single-stage pump: A pump in which the total head is developed by one impeller.

Stuffing box packing: The function of packing is to control leakage at the pump shaft, but it is not intended to eliminate it completely. Typically, an arrangement consisting of rings of packing, a lantern ring for the injection of a lubricating and/or flushing liquid, and a gland to hold the packing and maintain the desired compression for a proper seal. The packing is lubricated by the pumped liquid. The lantern ring is supplied for situations where the stuffing box pressure is below atmospheric pressure, to inject lubrication into the stuffing box by the use of a bypass line from the pump discharge to the lantern ring connection.

Total discharge head: The gauge reading in psi (kPa) at the discharge flange of the pump, referenced to the pump centerline, plus the velocity head at the point of gauge attachment.

Total suction head: The condition when the suction pressure is above atmospheric. The total suction head is the algebraic sum of the gauge reading in psi (kPa) at the pump suction nozzle flange, referenced to the pump centerline, and the velocity head at the point of gauge attachment. Also called “positive suction pressure.”

Total suction lift: The condition when suction pressure is below atmospheric. The total suction lift is the algebraic sum of the gauge reading in psi (kPa) at the suction nozzle flange of the pump, referenced to the pump centerline, and the velocity head at the point of gauge attachment.

Total head: The algebraic difference between the total discharge head and the total suction head. Where suction head exists, total head equals total discharge head minus total suction head. Where suction lift exists, total head equals total discharge head plus total suction lift

Variable-speed pressure-limiting control: A control system for limiting the discharge pressure produced by a fire pump by reducing the pump driver speed.

Suction pit: A defined area enclosed by open grates and screens filled with water from an open body of water such as a pond, river, or reservoir, used as a fire pump suction source.

APPENDIX B DOCUMENT REVISION HISTORY

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global’s loss prevention recommendations for ignitable liquid hazards.

July 2011. Minor editorial changes were made for this revision.

September 2010. Minor editorial changes were made for this revision.

May 2010. Replaced all references to Data Sheet 2-8N, *Installation of Sprinkler Systems (NFPA),* with references to Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

June 2009. Clarification was made to recommendation 2.8.4.10.

May 2008. Clarification was made to recommendation 2.3.3.2.

April 2008. Data Sheet 3-7 is new and supercedes Data Sheet 3-7N. The revision history of Data Sheet 3-7N can be found in the 2001 version of 3-7N.

December 2007. The following changes were made:

1. The data sheet number and title has been changed.
2. The data sheet has been completely rewritten.
3. Information on the use of variable speed pumps has been added.
4. Information on the use of mechanical seal pumps has been added.
5. Information on the use of positive displacement pumps has been added.
6. Information on steam turbine fire pumps has been retired.
7. High rise building pump installation requirements clarified.
8. New electrical feeder arrangement figures have been added.
9. Alert information on Cummins Campaign No. 8422, No. 8532, No. 8815, No. 9209 have been retired.

APPENDIX C ACCEPTANCE TESTING

The guidelines for water supply testing outlined in FM Global Data Sheet 3-0, *Hydraulics of Fire Protection Systems* should be followed in addition to these.

Prior to starting the pump, ensure the operator is familiar with the operation of this type of equipment. Ensure the instruction manuals issued by the engine, pump, and controller manufacturers are studied by all operators.

The following equipment is needed for testing:

a. Test valve header: Fifty-foot (15 m) lengths, 2 ½-in. (65 mm) lined hose with smooth bore nozzles (Underwriters' play pipes) as needed to flow required volume of water. (Where a calibrated and reliable in-line test flow meter is provided, these may not be needed.)

b. Use test instruments of high quality that are accurate and in good repair.

1. Clamp on volt/ammeter,
2. Test gages,
3. Tachometer, and
4. Pitot tube with gauge (for use with hose and nozzle).

c. Ensure that all test instrumentation has been calibrated within the last 12 months.

Flow Tests

Where a hose valve header is used, limit hose length to approximately 100 ft (30 m).

Where a flow test meter is used, provide additional outlets such as hydrants, hose valves, etc., to verify the accuracy of the metering device.

Test the flow meter for accuracy before the pump acceptance test to ensure it is installed correctly.

Field Acceptance Test Procedure

a. Make a visual check of the fire pump package. Verify the proper setting of pressure switches and circuit breakers. Check for signs of overheating and excessive vibration. If hose and nozzles are used, ensure they are securely tied down. Ensure the hose valves are closed. If a flow meter is used, verify the valve on the discharge side of the meter is closed. Verify the pressure in the mains is normal (i.e., jockey pump pressure) to prevent water hammer.

b. Evaluate the power source. For a diesel motor, ensure the fuel tank is full and the fuel supply valve is open. For an electric driver, verify the electrical supply routing is safeguarded against disruption by fire, collapse, flood, etc and that it is tied-in before the main facility disconnect.

c. Evaluate the suction supply. If a public supply, conduct a flow test with the pump turned off to verify this supply is sufficient and clear of debris. If a suction tank, ensure it is full and the supply valve is open. If an open body of water, ensure the screens are clear.

d. Start the pump.

e. Verify that the relief valve (if provided) is not flowing water.

f. Partially open one or two hose valves, or slightly open the meter discharge valve.

g. Check the general operation of the pump and driver. Watch for vibration, leaks (oil or water), unusual noises, and general operation; confirm slight water flow from packing glands.

h. Discharge of water:

1. Where a test valve header is used, regulate the discharge by means of the hose valves and selection of the nozzle tips. The play pipe has a removable 1 ⅛-in. (28.6 mm) tip and, when the tip is removed, the play pipe has a 1 ¾-in. (44.4 mm) nozzle.

2. When a test meter is used, regulate the discharge valve to achieve various flow readings.

3. Test the fire pump over its entire range of flow (0 to 150% of the rated capacity) by controlling the quantity of water discharged. Start at low flow and gradually increase it; starting the pump with hoses open can cause cavitation. Important test points are at churn (no flow), rated capacity, and 150% of rated capacity. Two intermediate points should be taken to help develop the performance curve.

i. Record the following data at each test point:

1. Pump rpm

2. Suction pressure

3. Discharge pressure

4. Number and size of hose nozzles, pitot pressure for each nozzle, and total gpm (L/min). For flow meter, record gpm (L/min).

5. Amperes (electric motors)

6. Volts (electric motors)

j. Calculation of test results:

1. Rated speed. Confirm pump is operating at rated rpm.

2. Capacity. For hose valve header, using nozzle discharge tables in *Hydraulics Tables* (P6920), determine the flow in gpm (L/min) for each nozzle at each pitot reading. An example: 16 psi (1.1 bar) pitot pressure with 1 ¾-in. (44.4 mm) nozzle with a coefficient of 0.97 indicates 364 gpm (1378 L/min). Add the flow for each hose line to determine total volume. For a flow meter, the total flow is read directly.

3. Net head. This is a measure of the actual work done by the pump, essentially the difference between the suction pressure and discharge pressures.

For horizontal pumps, this is the difference between the discharge pressure and the suction pressure.

For vertical pumps, this is the sum of the discharge pressure and the suction pressure. The suction pressure is calculated by multiplying 0.433 psi/ft (0.098 bar/m) by the height in ft (m) between the water level and the centerline of the pump discharge.

In both cases, if there is a significant difference between the effective point of the suction or discharge gauge and the pump centerline, this should be included.

4. Electrical input. Voltage and amperes are read directly from the volt/ammeter. This is compared to the motor nameplate full-load amperes. The only general calculation is to determine the maximum amperes allowed due to the motor service factor. In the case of 1.15 service factor, this is approximately 1.15 times motor amps, because changes in power factor and efficiency are not considered. If the maximum amps recorded on the test do not exceed this figure, the motor and pump will be judged satisfactory. It is most important to measure voltage and amperes accurately on each phase. This is important since poor power supply with low voltage will cause high ampere readings. This can be corrected only by improvement in the power supply; there is nothing that can be done to the motor or the pump.

5. Correction to rated speed. For purposes of plotting, correct the capacity, head, and power to the pump rated speed from those values obtained at test speed. The corrections are made as follows:

Capacity: Q2 = N2/N1 × Q1

Q1 = Flow at test speed in gpm (L/min)
Q2 = Flow at rated speed in gpm (L/min)
N1 = Test speed in rpm
N2 = Rated speed in rpm

Head: P2 = [N2/N1]2 × P1

P1 = Pressure at test speed in psi (bar)
P2 = Pressure at rated speed in psi(bar)

Horsepower: hp2 = [N2/N1]3 × hp1

hp1 = horsepower (kW) at test speed
hp2 = horsepower (kW) at rated speed

6. The final step in the test calculation is plotting the test points. A net head capacity curve is plotted and an ampere capacity curve is plotted. A study of these curves will show the performance picture of the pump as it was tested. This should be compared to the manufacturer's performance curve of the pump, when available.

k. Throughout the course of testing, start the pump 6 times manually and 6 times automatically to verify prompt and smooth start-up at the required pressures or flow. For electric motors, allow at least 5 minutes at full speed after each start-up to allow motor windings to cool properly.. For electric motors > 200hp (150kW), no more than 2 starts in 10 to 12 hours should be attempted, and a running interval of at least 15 minutes at full speed should be allowed.

l. Run the pump for at least 1 hour to verify smooth operation without coupling failure or overheating. For a diesel engine, check this by discharging at the 150% point, allowing the engine temperature to stabilize, and then run the pump for an additional 15 minutes. Engine overheating problems should be corrected immediately.

m. At the conclusion of the test, verify pressure in fire service mains is up to normal or up to jockey pump pressure before the pump is returned to automatic service in order to prevent water hammer. Verify all fire protection equipment is returned to the automatic mode and fire protection control valves fully open. Only the valve to the test header should remain closed.

Testing Variable-Speed Fire Pumps

Conduct flow testing with the variable speed pressure control both enabled and disabled.

In order to test the pump performance against the manufacturer's performance curve, test the pump with the pressure-limiting control disabled. In order to ensure the pressure limiting control is fully functional, test it over the entire range of pump flow.

Ensure the variable speed pressure limit is always above the highest facility pressure demand.

Acceptance Testing

In Figure 24, Curve A represents the theoretical characteristic curve for a 1500 gpm, 75 psi rated horizontal fire pump taking suction from the source shown by E. Curve B is more typical of actual pump performance.

Demand point C represents a high volume, moderate pressure system. The demand can be supplied by the pump.

Demand point D represents a low volume, high pressure system. The actual pump performance cannot meet the demand.

1 gpm = 3.8 liters/min
1 psi = 6.9 kPa = .069 bars Speed Correction

In field tests, actual speeds of diesel engines will vary from the rated speed. Pumps operated at a constant speed less than rated speed would produce curves parallel to but below the one for rated speed. The

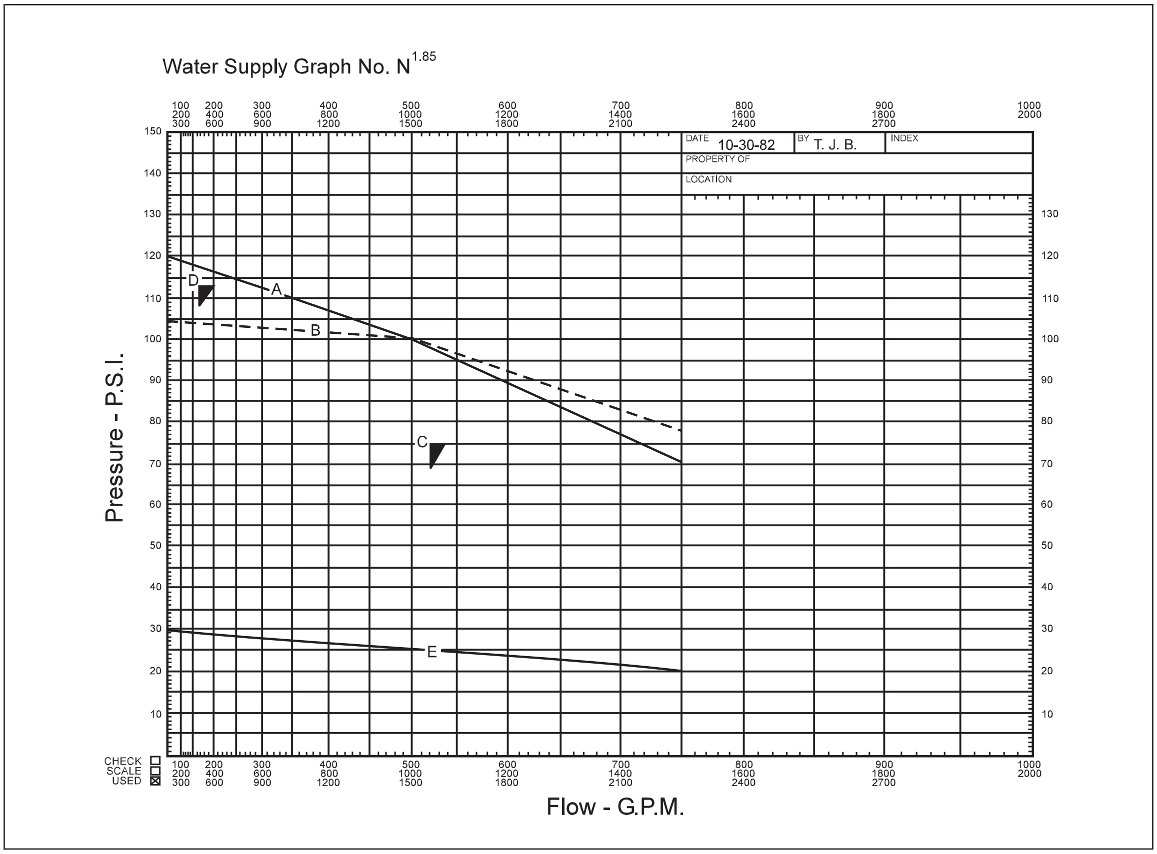


Fig. 24. Water supply graph

nameplate full load speed of an alternating current electric motor operating at rated voltage is accurate enough for test purposes that the use of speed counter is not necessary.

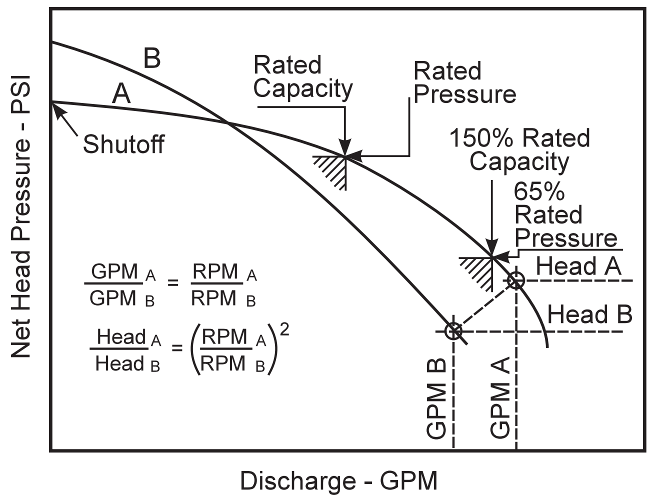
Curve B in Figure 25 is one produced by extreme variations from the rated pump speed.

These conditions indicate a problem with the driver and require correction.

If pump speed varies at some points, the flows and pressures may be normalized to what they would have been at rated speed, provided the pump is operated within the design limits of its suction lift This can be done by use of the following relations.

1. The gpm is proportional to the velocity of the water and, therefore, to the velocity of the impeller (or rpm).

2. Net head is proportional to the square of the velocity of the water and, therefore, to the square of the rpm.



A. Typical manufacturer's shop-test curve with pump operating at rated speed.
B. Field-test curve produced by extreme variations in speed, such as could occur with steam-turbine or internal-combustion-engine drive. Could be caused by insufficient power from steam turbine or faulty operation of internal-combustion-engine governor.

Fig. 25. Effect of variations in speed on pump performance curve