NFPA 20

Standard for the Installation of Stationary Pumps for Fire Protection

1999 Edition

This edition of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, was prepared by the Technical Committee on Fire Pumps and acted on by the National Fire Protection Association, Inc., at its May Meeting held May 17-20, 1999, in Baltimore, MD. It was issued by the Standards Council on July 22, 1999, with an effective date of August 13, 1999, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 20 was approved as an American National Standard on August 13, 1999.

Origin and Development of NFPA 20

The first National Fire Protection Association standard for automatic sprinklers was published in 1896 and contained paragraphs on steam and rotary fire pumps.

The Committee on Fire Pumps was organized in 1899 with five members from underwriter associations. Today the committee membership includes representatives of Underwriters Laboratories of both the United States and Canada, Insurance Services Offices, Factory Mutual, Industrial Risk Insurers, national trade associations, state government, engineering organizations, and private individuals.

Early fire pumps were only secondary supplies for sprinklers, standpipes, and hydrants, and were started manually. Today, fire pumps have greatly increased in number and in applications — many are the major or only water supply, and almost all are started automatically. Early pumps usually took suction by lift from standing or flowing water supplies because the famed National Standard Steam Fire Pump and rotary types suited that service. Ascendancy of the centrifugal pump resulted in positive head supply to horizontal shaft pumps from public water supplies and aboveground tanks. Later, vertical shaft turbine-type pumps were lowered into wells or into wet pits supplied from ponds or other belowground sources of water.

Gasoline engine-driven pumps first appeared in this standard in 1913. From an early status of relative unreliability and of supplementary use only, first spark-ignited gasoline engines and then compression ignition diesels have steadily developed engine-driven pumps to a place alongside electric-driven units for total reliability.

Fire protection now calls for larger pumps, higher pressures, and more varied units for a wide range of systems protecting both life and property. Hydraulically calculated and designed sprinkler and special fire protection systems have changed concepts of water supply completely.

Since the formation of this Committee, each edition of NFPA 20 has incorporated appropriate provisions to cover new developments and has omitted obsolete provisions. NFPA action on successive editions has been taken in the following years — 1907, 1910-13, 1915, 1918-21, 1923-29, 1931-33, 1937, 1939, 1943, 1944, 1946-48, 1951, 1953, 1955, 1957, 1959-72, 1974, 1976, 1978, 1980, 1983, 1987, 1990, 1993, 1996, and 1999.

The 1990 edition included several amendments with regard to some of the key components associated with electric-driven fire pumps. In addition, amendments were made to allow the document to conform more closely to the NFPA *Manual of Style*.

The 1993 edition included significant revisions to Chapters 6 and 7 with regard to the arrangement of the power supply to electric-driven fire pumps. These clarifications were intended to provide the necessary requirements in order to make the system as reliable as possible.

The 1996 edition continued the changes initiated in the 1993 edition as Chapters 6 and 7, which addressed electric drives and controllers, underwent significant revision. New information was also added regarding engine-cooling provisions, earthquake protection, and backflow preventers. Chapter 5, which addressed provisions for high-rise buildings, was removed, as were capacity limitations on in-line and end-suction pumps. Additionally, provisions regarding suction pipe fittings were updated.

The 1999 edition of the standard includes requirements for positive displacement pumps for both water mist and foam systems. The document title was revised to reflect this change, since the standard now addresses requirements for pumps other than centrifugal. Enforceable language was added, particularly regarding protection of equipment.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the selection and installation of stationary pumps supplying water or special additives including but not limited to foam concentrates for private fire protection, including suction piping, valves and auxiliary equipment, electric drive and control equipment, and internal combustion engine drive and control equipment.

NFPA 20

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

A reference in parentheses () at the end of a section or paragraph indicates that the material has been extracted from another NFPA document. The bold number in parentheses indicates the document number and is followed by the section number where the extracted material can be found in that document. The complete title and current edition of an extracted document can be found in the chapter on referenced publications.

Information on referenced publications can be found in Chapter 12 and Appendix C.

Chapter 1 Introduction

1-1* Scope.

This standard deals with the selection and installation of pumps supplying water for private fire protection. Items considered include water supplies; suction, discharge, and auxiliary equipment; power supplies; electric drive and control; internal combustion engine drive and control; steam turbine drive and control; and acceptance tests and operation. This standard does not cover system water supply capacity and pressure requirements *(see A-2-1.1)*, nor does it cover requirements for periodic inspection, testing, and maintenance of fire pump systems. This standard does not cover the requirements for installation wiring of fire pump units.

1-2 Purpose.

1-2.1

The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through installation requirements for stationary pumps for fire protection based upon sound engineering principles, test data, and field experience. This standard includes single-stage and multistage pumps of horizontal or vertical shaft design. Requirements are established for the design and installation of these pumps, pump drivers, and associated equipment. The standard endeavors to continue the excellent record that has been established by stationary pump installations and to meet the needs of changing technology. Nothing in this standard is intended to restrict new technologies or alternate arrangements provided the level of safety prescribed by the standard is not lowered.

1-2.2 Existing Installations.

Where existing pump installations meet the provisions of the standard in effect at the time of purchase, they shall be permitted to remain in use provided they do not constitute a distinct hazard to life or adjoining property.

1-3 Other Pumps.

Pumps other than those specified in this standard and having different design features shall be permitted to be installed where such pumps are listed by a testing laboratory. They shall be limited to capacities of less than 500 gpm (1892 L/min).

1-4* Approval Required.

1-4.1

Stationary pumps shall be selected based on the conditions under which they are to be installed and used.

1-4.2

The pump manufacturer or its designated representative shall be given complete information concerning the water and power supply characteristics.

1-4.3

A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and water supply conditions shall be prepared for approval. Each pump, driver, controlling equipment, power supply and arrangement, and water supply shall be approved by the authority having jurisdiction for the specific field conditions encountered.

1-5 Pump Operation.

In the event of fire pump operation, qualified personnel shall respond to the fire pump location to determine that the fire pump is operating in a satisfactory manner.

1-6 Unit Performance.

1-6.1*

The unit, consisting of a pump, driver, and controller, shall perform in compliance with this standard as an entire unit when installed or when components have been replaced.

1-6.2

The complete unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. *(See Section 11-2.)*

1-7 Certified Shop Test.

Certified shop test curves showing head capacity and brake horsepower of the pump shall be furnished by the manufacturer to the purchaser. The purchaser shall furnish this data to the authority having jurisdiction.

1-8 Definitions.

Additive. A liquid such as foam concentrates, emulsifiers, and hazardous vapor suppression liquids and foaming agents intended to be injected into the water stream at or above the water pressure.

Approved.* Acceptable to the authority having jurisdiction.

Aquifer. An underground formation that contains sufficient saturated permeable material to yield significant quantities of water.

Aquifer Performance Analysis. A test designed to determine the amount of underground water available in a given field and proper well spacing to avoid interference in that field. Basically, test results provide information concerning transmissibility and storage coefficient (available volume of water) of the aquifer.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

Automatic Transfer Switch. Self-acting equipment for transferring one or more 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.

Can Pump. A vertical shaft turbine-type pump in a can (suction vessel) for installation in a pipeline to raise water pressure.

Centrifugal Pump. A pump in which the pressure is developed principally by the action of centrifugal force.

Corrosion-Resistant Material. Materials such as brass, copper, monel, stainless steel, or other equivalent corrosion-resistant materials.

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. The oil-diesel engine, which operates on fuel oil injected after compression is practically completed, is the type usually used as a fire pump driver.

Disconnecting Means. A device, group of devices, or other means (e.g., the circuit breaker in the fire pump controller) by which the conductors of a circuit can be disconnected from their source of supply.

Drawdown. The vertical difference between the pumping water level and the static water level.

Dripproof Guarded Motor. A dripproof machine whose ventilating openings are guarded in accordance with the definition for *dripproof motor*.

Dripproof Motor. An open motor in which the ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle from 0 to 15 degrees downward from the vertical.

Dust-Ignition-Proof Motor. A totally enclosed motor whose enclosure is designed and constructed in a manner that will exclude ignitable amounts of dust or amounts that might affect performance or rating and that will not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specific dust on or in the vicinity of the enclosure.

Electric Motors. Motors that are classified according to mechanical protection and methods of cooling.

End Suction Pump. A single suction pump having its suction nozzle on the opposite side of the casing from the stuffing box and having the face of the suction nozzle perpendicular to the longitudinal axis of the shaft.

Explosionproof Motor. A totally enclosed motor whose enclosure is designed and constructed to withstand an explosion of a specified gas or vapor that could occur within it and to prevent the ignition of the specified gas or vapor surrounding the motor by sparks, flashes, or explosions of the specified gas or vapor that could occur within the motor casing.

Feeder. All circuit conductors between the service equipment or the source of a separately derived system and the final branch-circuit overcurrent device.

Fire Pump Controller. A group of devices that serve to govern, in some predetermined manner, the starting and stopping of the fire pump driver as well as monitoring and signaling the status and condition of the fire pump unit.

Fire Pump Unit. An assembled unit consisting of a fire pump, driver, controller, and accessories.

Flexible Connecting Shaft. A device that incorporates two flexible joints and a telescoping element.

Flexible Coupling. A device used to connect the shafts or other torque-transmitting components from a driver to the pump, and that permits minor angular and parallel misalignment as restricted by both the pump and coupling manufacturers.

Flooded Suction. The condition where water flows from an atmospheric vented source to the pump without the average pressure at the pump inlet flange dropping below atmospheric pressure with the pump operating at 150 percent of its rated capacity.

Flow Unloader Valve. A valve that is designed to relieve excess flow below pump capacity at set pump pressure.

Groundwater. That water that is available from a well, driven into water-bearing subsurface strata (aquifer).

Guarded Motor. An open motor in which all openings giving direct access to live metal or rotating parts (except smooth rotating surfaces) are limited in size by the structural parts or by screens, baffles, grilles, expanded metal, or other means to prevent accidental contact with hazardous parts. Openings giving direct access to such live or rotating parts shall not permit the passage of a cylindrical rod 0.75 in. (19 mm) in diameter.

Head.* A quantity used to express a form (or combination of forms) of the energy content of water per unit weight of the water referred to any arbitrary datum.

Horizontal Pump. A pump with the shaft normally in a horizontal position.

Horizontal Split-Case Pump. A centrifugal pump characterized by a housing that is split parallel to the shaft.

Internal Combustion Engine. Any engine in which the working medium consists of the products of combustion of the air and fuel supplied. This combustion usually is effected within the working cylinder but can take place in an external chamber.

Isolating Switch. A switch intended for isolating an electric circuit from its source of power. It has no interrupting rating and it is intended to be operated only after the circuit has been opened by some other means.

Listed.* Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

Manual Transfer Switch. A switch operated by direct manpower for transferring one or more load conductor connection from one power source to another.

Maximum Pump Brake Horsepower. The maximum brake horsepower required to drive the pump at rated speed. The pump manufacturer determines this by shop test under expected suction and discharge conditions. Actual field conditions can vary from shop conditions.

Net Positive Suction Head (NPSH) (h_{sv}). The total suction head in feet (meters) of liquid absolute, determined at the suction nozzle, and referred to datum, less the vapor pressure of the liquid in feet (meters) absolute.

Open Motor. A motor having ventilating openings that permit passage of external cooling air over and around the windings of the motor. Where applied to large apparatus without qualification, the term designates a motor having no restriction to ventilation other than that necessitated by mechanical construction.

Pump, Additive. A pump that is used to inject additives into the water stream.

Pump, Foam Concentrate. See definition of *Pump, Additive*.

Pump, Gear. A positive displacement pump characterized by the use of gear teeth and casing to displace liquid.

Pump, In-Line. A centrifugal pump whose drive unit is supported by the pump having its suction and discharge flanges on approximately the same centerline.

Pump, Piston Plunger. A positive displacement pump characterized by the use of a piston or plunger and cylinder to displace liquid.

Pump, Positive Displacement. A pump that is characterized by a method of producing flow by capturing a specific volume of fluid per pump revolution and reducing the fluid void by a mechanical means to displace the pumping fluid.

Pump, Rotary Lobe. A positive displacement pump characterized by the use of a rotor lobe to carry fluid between the lobe void and the pump casing from the inlet to the outlet.

Pump, Rotary Vane. A positive displacement pump characterized by the use of a single rotor with vanes that move with pump rotation to create a void and displace liquid.

Pumping Water Level. The level, with respect to the pump, of the body of water from which it takes suction when the pump is in operation. Measurements are made the same as with the static water level.

Service.* The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service Equipment.* The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building, other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service Factor. A multiplier of an ac motor that, when applied to the rated horsepower, indicates a permissible horsepower loading that can be carried at the rated voltage, frequency, and temperature. For example, the multiplier 1.15 indicates that the motor is permitted to be overloaded to 1.15 times the rated horsepower.

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Static Water Level. The level, with respect to the pump, of the body of water from which it takes suction when the pump is not in operation. For vertical shaft turbine-type pumps, the distance to the water level is measured vertically from the horizontal centerline of the discharge head or tee.

Total Discharge Head *(hd)*. The reading of a pressure gauge at the discharge of the pump, converted to feet (meters) of liquid, and referred to datum, plus the velocity head at the point of gauge attachment.

Total Head *(H)*, Horizontal Pumps.* The measure of the work increase per pound (kilogram) of liquid, imparted to the liquid by the pump, and therefore the algebraic difference between the total discharge head and the total suction head. Total head, as determined on test where suction lift exists, is the sum of the total discharge head and total suction lift. Where positive suction head exists, the total head is the total discharge head minus the total suction head.

Total Head *(H)*, Vertical Turbine Pumps.* The distance from the pumping water level to the center of the discharge gauge plus the total discharge head.

Total Rated Head. The total head developed at rated capacity and rated speed for either a horizontal split-case or a vertical shaft turbine-type pump.

Total Suction Head *(hs)*. Suction head exists where the total suction head is above atmospheric pressure. Total suction head, as determined on test, is the reading of a gauge at the suction of the pump, converted to feet (meters) of liquid, and referred to datum, plus the velocity head at the point of gauge attachment.

Total Suction Lift *(hl)*. Suction lift exists where the total suction head is below atmospheric pressure. Total suction lift, as determined on test, is the reading of a liquid manometer at the suction nozzle of the pump, converted to feet (meters) of liquid, and referred to datum, minus the velocity head at the point of gauge attachment.

Totally Enclosed Fan-Cooled Motor. A totally enclosed motor equipped for exterior cooling by means of a fan or fans integral with the motor but external to the enclosing parts.

Totally Enclosed Motor. A motor enclosed so as to prevent the free exchange of air between the inside and the outside of the case but not sufficiently enclosed to be termed airtight.

Totally Enclosed Nonventilated Motor. A totally enclosed motor that is not equipped for cooling by means external to the enclosing parts.

Velocity Head (h_v).* The velocity head is figured from the average velocity (v) obtained by dividing the flow in cubic feet per second (cubic meters per second) by the actual area of pipe cross section in square feet (square meters) and determined at the point of the gauge connection.

Vertical Lineshaft Turbine Pump. A vertical shaft centrifugal pump with rotating impeller or impellers and with discharge from the pumping element coaxial with the shaft. The pumping element is suspended by the conductor system, which encloses a system of vertical shafting used to transmit power to the impellers, the prime mover being external to the flow stream.

Wet Pit. A timber, concrete, or masonry enclosure having a screened inlet kept partially filled with water by an open body of water such as a pond, lake, or stream.

1-8.1 Additional Definitions.

Additional applicable definitions can be found in the latest edition of *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps* and NFPA 70, *National Electrical Code®*.

1-9 Units.

Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-9 with conversion factors.

Table 1-9 International System of Units

Name of Unit	Unit Symbol	Conversion Factor
meter	m	1 ft = 0.3048 m
millimeter	mm	1 in. = 25.4 mm
liter	L	1 gal = 3.785 L
cubic decimeter	dm^3	1 gal = 3.785 dm^3
cubic meter	m^3	1 ft^3 = 0.0283 m^3
pascal	Pa	1 psi = 6894.757 Pa

Name of Unit	Unit Symbol	Conversion Factor
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

Note: For additional conversions and information, see ASTM E 380, *Standard for Metric Practice*.

1-9.1

If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value is considered to be approximate.

1-9.2

The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the approximate number of significant digits.

Chapter 2 General

2-1 Water Supplies.

2-1.1* Reliability.

The adequacy and dependability of the water source are of primary importance and shall be fully determined, with due allowance for its reliability in the future. *(See A-2-1.1.)*

2-1.2* Sources.

Any source of water that is adequate in quality, quantity, and pressure shall be permitted to provide the supply for a fire pump. Where the water supply from a public service main is not adequate in quality, quantity, or pressure, an alternative water source shall be provided. The adequacy of the water supply shall be determined and evaluated prior to the specification and installation of the fire pump.

2-1.3 Level.

The minimum water level of a well or wet pit shall be determined by pumping at not less than 150 percent of the fire pump rated capacity.

2-1.4* Stored Supply.

A stored supply shall be sufficient to meet the demand placed upon it for the expected duration and a reliable method of replenishing the supply shall be provided.

2-1.5 Head.

The head available from a water supply shall be figured on the basis of a flow of 150 percent of rated capacity of the fire pump. This head shall be as indicated by a flow test.

2-2 Pumps and Drivers.

2-2.1

Centrifugal fire pumps shall be listed for fire protection service.

2-2.2

Acceptable drivers for pumps at a single installation are electric motors, diesel engines, steam turbines, or a combination thereof.

2-2.3

Except for installations made prior to adoption of the 1974 edition of this standard, dual-drive pump units shall not be used.

2-2.4*

The net pump shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, shall not exceed the pressure for which the system components are rated.

2-3* Rated Pump Capacities.

Fire pumps shall have the following rated capacities in gpm (L/min) and shall be rated at net pressures of 40 psi (2.7 bar) or more *(see Table 2-3)*. Pumps for ratings over 5000 gpm (18,925 L/min) are subject to individual review by either the authority having jurisdiction or a listing laboratory.

Table 2-3 Rated Pump Capacities

gpm	L/min
25	95
50	189
100	379
150	568
200	757
250	946
300	1,136
400	1,514
450	1,703
500	1,892
750	2,839
1,000	3,785
1,250	4,731
1,500	5,677
2,000	7,570
2,500	9,462
3,000	11,355
3,500	13,247

gpm	L/min
4,000	15,140
4,500	17,032
5,000	18,925

2-4 Nameplate.

Pumps shall be provided with a nameplate.

2-5 Pressure Gauges.

2-5.1

A pressure gauge having a dial not less than 3$^1/_2$ in. (89 mm) in diameter shall be connected near the discharge casting with a $^1/_4$-in. (6.25-mm) gauge valve. The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than 200 psi (13.8 bar). The face of the dial shall read in pounds per square inch, bar, or both with the manufacturer's standard graduations.

2-5.2*

A compound pressure and vacuum gauge having a dial not less than 3$^1/_2$ in. (89 mm) in diameter shall be connected to the suction pipe near the pump with a $^1/_4$-in. (6.25-mm) gauge valve.

Exception: This rule shall not apply to vertical shaft turbine-type pumps taking suction from a well or open wet pit.

The face of the dial shall read in inches of mercury (millimeters of mercury) or pounds per square inch (bar) for the suction range. The gauge shall have a pressure range two times the rated maximum suction pressure of the pump, but not less than 100 psi (7 bar).

2-6 Circulation Relief Valve.

2-6.1

Each pump(s) shall have an automatic relief valve listed for the fire pump service installed and set below the shutoff pressure at minimum expected suction pressure. The valve shall be installed on the discharge side of the pump before the discharge check valve. It shall provide flow of sufficient water to prevent the pump from overheating when operating with no discharge. Provisions shall be made for discharge to a drain. Circulation relief valves shall not be tied in with the packing box or drip rim drains.

Minimum size of the automatic relief valve shall be $^3/_4$ in. (19.0 mm) for pumps with a rated capacity not exceeding 2500 gpm (9462 L/min), and 1 in. (25.4 mm) for pumps with a rated capacity of 3000 to 5000 gpm (11,355 to 18,925 L/min).

Exception: This rule shall not apply to engine-driven pumps for which engine cooling *water is taken from the pump discharge.*

2-6.2

Where a pressure relief valve has been piped back to suction, a circulation relief valve shall be provided. The size shall be in accordance with Section 2-6.

2-7* Equipment Protection.

2-7.1*

The fire pump, driver, and controller shall be protected against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism, and other adverse conditions.

2-7.1.1

Indoor fire pump units shall be separated from all other areas of the building by 2-hour fire-rated construction.

Exception No. 1: The pumps outlined in 2-7.1.2.

Exception No. 2: In buildings protected with an automatic sprinkler system installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, the separation requirement shall be reduced to 1-hour fire-rated construction.

2-7.1.2

Fire pump units located outdoors and fire pump installations in buildings other than that building being protected by the fire pump shall be located at least 50 ft (15.3 m) away from the protected building. Outdoor installations also shall be required to be provided with protection against possible interruption in accordance with 2-7.1.

2-7.2

Suitable means shall be provided for maintaining the temperature of a pump room or pump house, where required, above 40°F (5°C).

Exception: See 8-6.5 for higher temperature requirements for internal combustion engines.

2-7.3

Artificial light shall be provided in a pump room or pump house.

2-7.4

Emergency lighting shall be provided by fixed or portable battery-operated lights, including flashlights. Emergency lights shall not be connected to an engine-starting battery.

2-7.5

Provision shall be made for ventilation of a pump room or pump house.

2-7.6*

Floors shall be pitched for adequate drainage of escaping water away from critical equipment such as the pump, driver, controller, and so forth. The pump room or pump house shall be provided with a floor drain that will discharge to a frost-free location.

2-7.7

Guards shall be provided for flexible couplings and flexible connecting shafts to prevent rotating elements from causing injury to personnel.

2-8 Pipe and Fittings.

2-8.1*

Steel pipe shall be used above ground except for connection to underground suction and underground discharge piping. Where corrosive water conditions exist, steel suction pipe shall be galvanized or painted on the inside prior to installation with a paint recommended for submerged surfaces. Thick bituminous linings shall not be used.

2-8.2*

Sections of steel piping shall be joined by means of screwed, flanged mechanical grooved joints, or other approved fittings.

Exception: Slip-type fittings shall be permitted to be used where installed as required by 2-9.6 and where the piping is mechanically secured to prevent slippage.

2-8.3

Foam concentrate or additive piping shall be a material that will not corrode in this service. Galvanized pipe shall not be used for foam concentrate service.

2-8.4*

Torch-cutting or welding in the pump house shall be permitted as a means of modifying or repairing pump house piping when it is performed in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

2-9 Suction Pipe and Fittings.

2-9.1* Components.

The suction components shall consist of all pipe, valves, and fittings from the pump suction flange to the connection to the public or private water service main, storage tank, or reservoir, and so forth, that feeds water to the pump. Where pumps are installed in series, the suction pipe for the subsequent pump(s) shall begin at the system side of the discharge valve of the previous pump.

2-9.2 Installation.

Suction pipe shall be installed and tested in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

2-9.3 Suction Size.

The size of the suction pipe for a single pump or of the suction header pipe for multiple pumps (operating together) shall be such that, with all pumps operating at 150 percent of rated capacity, the gauge pressure at the pump suction flanges shall be 0 psi (0 bar) or higher. The suction pipe shall be sized such that, with the pump(s) operating at 150 percent of rated capacity, the velocity in that portion of the suction pipe located within 10 pipe diameters upstream of the pump suction flange does not exceed 15 ft/sec (4.57 m/sec). The size of that portion of the suction pipe located within 10 pipe diameters upstream of the pump suction flange shall be not less than that specified in Table 2-20.

Exception: Where the water supply is a suction tank with its base at or above the same elevation as the pump, the gauge pressure at the pump suction flange shall be permitted to drop to -3 psi (0.14 kPa.)

2-9.4* Pumps with Bypass.

Where the suction supply is of sufficient pressure to be of material value without the pump, the pump shall be installed with a bypass. *(See Figure A-2-9.4.)* The size of the bypass shall be at least as large as the pipe size required for discharge pipe as specified in Table 2-20.

2-9.5* Valves.

A listed outside screw and yoke (OS&Y) gate valve shall be installed in the suction pipe. No valve other than a listed OS&Y valve shall be installed in the suction pipe within 50 ft (16 m) of the pump suction flange.

2-9.6* Installation.

2-9.6.1

Suction pipe shall be laid carefully to avoid air leaks and air pockets, either of which can seriously affect the operation of the pump. *(See Figure A-2-9.6.)*

2-9.6.2

Suction pipe shall be installed below the frost line or in frostproof casings. Where pipe enters streams, ponds, or reservoirs, special attention shall be given to prevent freezing either under ground or under water.

2-9.6.3

Elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft shall be avoided. *(See Figure A-2-9.6.)*

Exception: Elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft shall be permitted where the distance between the flanges of the pump suction intake *and the elbow and tee is greater than 10 times the suction pipe diameter.*

2-9.6.4

Where the suction pipe and pump suction flange are not of the same size, they shall be connected with an eccentric tapered reducer or increaser installed in such a way as to avoid air pockets. *(See Figure A-2-9.6.)*

2-9.6.5

Where the pump and its suction supply are on separate foundations with rigid interconnecting pipe, the pipe shall be provided with strain relief. *(See Figure A-3-3.1.)*

2-9.7 Multiple Pumps.

Where a single suction pipe supplies more than one pump, the suction pipe layout at the pumps shall be arranged so that each pump will receive its proportional supply.

2-9.8* Suction Screening.

Where the water supply is obtained from an open source such as a pond or wet pit, the passage of materials that could clog the pump shall be obstructed. Double removable intake screens shall be provided at the suction intake. Below minimum water level these screens shall have an effective net area of openings of 1 in.^{2} (645 mm^2) for each gpm (3.785 L/min) at 150 percent of rated pump capacity. Screens shall be so arranged that they can be cleaned or repaired without disturbing the suction pipe. A brass, copper, monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of $^1/_2$-in. (12.7-mm) mesh and No. 10 Brown & Sharpe (B. & S.) gauge wire shall be secured to a metal frame sliding vertically at the entrance to the intake. The overall area of this particular screen shall be 1.6 times the net screen opening area. *(See screen details in Figure A-4-2.2.2.)*

2-9.9* Devices in Suction Piping.

The requirements for devices in suction piping shall be as follows.

(1) No device or assembly, including, but not limited to, backflow prevention devices or assemblies, that will stop, restrict the starting, or restrict the discharge of a fire pump or pump driver shall be installed in the suction piping.

Exception No. 1: Except as specified in 2-9.5.

Exception No. 2: Check valves and backflow prevention devices and assemblies shall be permitted where required by other NFPA standards or the authority having jurisdiction.

Exception No. 3: Flow control valves that are listed for fire pump service and that are suction pressure sensitive shall be permitted where the authority having jurisdiction requires positive pressure to be maintained on the suction piping.

(2) Suitable devices shall be permitted to be installed in the suction supply piping or stored water supply and arranged to activate an alarm if the pump suction pressure or water level falls below a predetermined minimum.

2-9.10* Vortex Plate.

For pump(s) taking suction from a stored water supply, a vortex plate shall be installed at the entrance to the suction pipe. *(See Figure A-3-3.1.)*

2-10 Discharge Pipe and Fittings.

2-10.1

The discharge components shall consist of pipe, valves, and fittings extending from the pump discharge flange to the system side of the discharge valve.

2-10.2*

The pressure rating of the discharge components shall be adequate for the maximum working pressure but not less than the rating of the fire protection system. Steel pipe with flanges, screwed joints, or mechanical grooved joints shall be used above ground. All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

2-10.3*

The size of pump discharge pipe and fittings shall not be less than that given in Table 2-20.

2-10.4*

A listed check valve or backflow preventer shall be installed in the pump discharge assembly.

2-10.5

A listed indicating gate or butterfly valve shall be installed on the fire protection system side of the pump discharge check valve. Where pumps are installed in series, a butterfly valve shall not be installed between pumps.

2-11* Valve Supervision.

Where provided, the suction valve, discharge valve, bypass valves, and isolation valves on the backflow prevention device or assembly shall be supervised open by one of the following methods:

(1) Central station, proprietary, or remote station signaling service

(2) Local signaling service that will cause the sounding of an audible signal at a constantly attended point

(3) Locking valves open

(4) Sealing of valves and approved weekly recorded inspection where valves are located within fenced enclosures under the control of the owner

Exception: The test outlet control valves shall be supervised closed.

2-12* Protection of Piping Against Damage Due to Movement.

A clearance of not less than 1 in. (25.4 mm) shall be provided around pipes that pass through walls or floors.

2-13 Relief Valve.

2-13.1*

Where a diesel engine-driven fire pump is installed and 121 percent of the net rated shutoff (churn) pressure plus the maximum static suction pressure, adjusted for elevation, exceeds the pressure for which the system components are rated, a relief valve shall be provided.

2-13.2

The relief valve size shall not be less than that given in Table 2-20. *(See also 2-13.7 and A-2-13.7 for conditions affecting size.)*

2-13.3

The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

2-13.4

Pressure relief valves shall be either a listed spring-loaded or pilot-operated diaphragm type.

2-13.4.1

Pilot-operated pressure relief valves, where attached to vertical shaft turbine pumps, shall be arranged to prevent relieving of water at water pressures less than the pressure relief setting of the valve.

2-13.5*

The relief valve shall discharge into an open pipe or into a cone or funnel secured to the outlet of the valve. Water discharge from the relief valve shall be readily visible or easily detectable by the pump operator. Splashing of water into the pump room shall be avoided. If a closed-type cone is used, it shall be provided with means for detecting motion of water through the cone. If the relief valve is provided with means for detecting motion (flow) of water through the valve, then cones or funnels at its outlet shall not be required.

2-13.6

The relief valve discharge pipe from an open cone shall be of a size not less than that given in Table 2-20. If the pipe employs more than one elbow, the next larger pipe size shall be used.

2-13.7*

Where the relief valve is piped back to the source of supply, the relief valve and piping shall have sufficient capacity to prevent pressure from exceeding that for which system components are rated.

2-13.8*

Where the supply of water to the pump is taken from a suction reservoir of limited capacity, the drain pipe shall discharge into the reservoir at a point as far from the pump suction as is necessary to prevent the pump from drafting air introduced by the drain pipe discharge.

2-13.9

A shutoff valve shall not be installed in the relief valve supply or discharge piping.

2-13.10

Relief valve discharge piping returning water back to the supply source such as an aboveground storage tank shall be run independently and not be combined with the discharge from other relief valves.

2-14 Water Flow Test Devices.

2-14.1 General.

2-14.1.1

A fire pump installation shall be arranged to allow the test of the pump at its rated conditions as well as the suction supply at the maximum flow available from the fire pump.

2-14.1.2*

Where water usage or discharge is not permitted for the duration of the test specified in Chapter 11, the outlet shall be used to test the pump and suction supply and determine that the system is operating in accordance with the design. The flow shall continue until flow has stabilized. *(See 11-2.6.3.)*

2-14.2 Meters.

2-14.2.1*

Metering devices or fixed nozzles for pump testing shall be listed. They shall be capable of water flow of not less than 175 percent of rated pump capacity.

2-14-2.2

All of the meter system piping shall be sized as specified by the meter manufacturer but not less than the meter device sizes shown in Table 2-20.

2-14.2.3

The minimum size meter for a given pump capacity shall be permitted to be used where the meter system piping does not exceed 100 ft (30 m) equivalent length. Where meter system piping exceeds 100 ft (30 m), including length of straight pipe plus equivalent length in fittings, elevation, and loss through meter, the next larger size of piping shall be used to minimize friction loss. The primary element shall be suitable for that pipe size and pump rating. The readout instrument shall be sized for the pump-rated capacity. *(See Table 2-20.)*

2-14.3 Hose Valves.

2-14.3.1*

Hose valves shall be listed. The number and size of hose valves used for pump testing shall be as specified in Table 2-20. Hose valves shall be mounted on a hose valve header and supply piping shall be sized according to Table 2-20.

2-14.3.2

Hose valve(s) shall have the NH standard external thread for the valve size specified, as specified in NFPA 1963, *Standard for Fire Hose Connections*.

Exception: Where local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall designate the threads to be used.

2-14.3.3

Where the hose valve header is located outside or at a distance from the pump and there is danger of freezing, a listed indicating or butterfly gate valve and drain valve or ball drip shall be located in the pipeline to the hose valve header. The valve shall be at a point in the line close to the pump. *(See Figure A-3-3.1.)*

2-14.3.4

Where the pipe between the hose valve header and connection to the pump discharge pipe is over 15 ft (4.5 m) in length, the next larger pipe size shall be used.

Exception: This pipe is permitted to be sized by hydraulic calculations based on a total flow of 150 percent of rated pump capacity. This calculation shall include friction loss for the total length of pipe plus equivalent lengths of fittings, control valve, and hose valves, plus elevation loss, from the pump discharge flange to the hose valve outlets. The installation shall be proven by a test flowing the maximum water available.

2-15 Power Supply Dependability.

2-15.1 Electric Supply.

Careful consideration shall be given in each case to the dependability of the electric supply system and the wiring system. Consideration shall include the possible effect of fire on transmission lines either in the property or in adjoining buildings that could threaten the property.

2-15.2 Steam Supply.

Careful consideration shall be given in each case to the dependability of the steam supply and the steam supply system. Consideration shall include the possible effect of fire on transmission piping either in the property or in adjoining buildings that could threaten the property.

2-16 Shop Tests.

2-16.1

Each individual pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with specifications.

2-16.2

Before shipment from the factory, each pump shall be hydrostatically tested by the manufacturer for a period of time not less than 5 minutes. The test pressure shall not be less than $1^1/_2$ times the sum of the pump's shutoff head plus its maximum allowable suction head, but in no case shall it be less than 250 psi (17 bar). Pump casings shall be essentially tight at the test pressure. During the test, no objectionable leakage shall occur at any joint. In the case of vertical turbine-type pumps, both the discharge casting and pump bowl assembly shall be tested.

2-17* Pump Shaft Rotation.

Pump shaft rotation shall be determined and correctly specified when ordering fire pumps and equipment involving that rotation.

2-18* Alarms.

When required by other sections of this standard, alarms shall call attention to improper conditions in the fire pump equipment.

2-19* Pressure Maintenance (Jockey or Make-Up) Pumps.

2-19.1

Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate. The pumps shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

2-19.2

A check valve shall be installed in the discharge pipe.

2-19.3*

Indicating butterfly or gate valves shall be installed in such places as needed to make the pump, check valve, and other miscellaneous fittings accessible for repair. *(See Figure A-2-19.3.)*

2-19.4*

Where a centrifugal-type pressure maintenance pump has a shutoff pressure exceeding the working pressure rating of the fire protection equipment, or where a turbine vane (peripheral) type of pump is used, a relief valve sized to prevent overpressuring of the system shall be installed on the pump discharge to prevent damage to the fire protection system. Running period timers shall not be used where jockey pumps are utilized that have the capability of exceeding the working pressure of the fire protection systems.

2-19.5

The primary or standby fire pump shall not be used as a pressure maintenance pump.

2-19.6

Steel pipe shall be used for suction and discharge piping on jockey pumps, which includes packaged prefabricated systems.

2-20 Summary of Fire Pump Data.

The sizes indicated in Table 2-20 shall be used.

2-21 Backflow Preventers and Check Valves.

2-21.1

Check valves and backflow prevention devices and assemblies shall be listed for fire protection service.

2-21.2

Where the backflow prevention device or assembly incorporates a relief valve, the relief valve shall discharge to a drain appropriately sized for the maximum anticipated flow. An air gap shall be provided in accordance with the manufacturer’s recommendations. Water discharge from the relief valve shall be readily visible or easily detectable. Performance of the preceding requirements shall be documented by engineering calculations and tests.

2-21.3

Where located in the suction pipe of the pump, check valves and backflow prevention devices or assemblies shall be located a minimum of 10 pipe diameters from the pump suction flange.

2-21.4

Where the authority having jurisdiction requires the installation of a backflow prevention device or assembly in connection with the pump, special consideration shall be given to the increased pressure loss resulting from the installation. Under these circumstances, it is critical to ensure the final arrangement shall provide effective pump performance with a minimum suction pressure of 0 psi (0 bar) at the gauge at 150 percent of rated capacity.

Determination of effective pump performance shall be documented by engineering calculations and tests.

2-22 Earthquake Protection.

2-22.1*

Where local codes require seismic design, the fire pump, driver, diesel fuel tank (where installed), and fire pump controller shall be attached to their foundations with materials capable of resisting lateral movement of horizontal forces equal to one-half of the weight of the equipment.

Exception: Where the authority having jurisdiction requires horizontal force factors other than 0.5, NFPA 13, Standard for the Installation of Sprinkler Systems, shall apply.

2-22.2

Pumps with high centers of gravity, such as vertical in-line pumps, shall be mounted at their base and braced above their center of gravity in accordance with the requirements of 2-22.1.

2-22.3

Where the system riser is also a part of the fire pump discharge piping, a flexible pipe coupling shall be installed at the base of the system riser.

2-23 Field Acceptance Test of Pump Units.

Upon completion of the entire fire pump installation, an acceptance test shall be conducted in accordance with the provisions of this standard. *(See Chapter 11.)*

Table 2-20 Summary of Fire Pump Data

		Minimum Pipe Sizes (Nominal)				
Pump Rating		Suction[1, 2] (in.)	Discharge[1] (in.)	Relief Valve (in.)	Relief Valve Discharge (in.)	Meter I (in.
gpm	L/min					
25	95	1	1	3/4	1	1 1/
50	189	1 1/2	1 1/4	1 1/4	1 1/2	2
100	379	2	2	1 1/2	2	2 1/
150	568	2 1/2	2 1/2	2	2 1/2	3
200	757	3	3	2	2 1/2	3
250	946	3 1/2	3	2	2 1/2	3 1/
300	1,136	4	4	2 1/2	3 1/2	3 1/
400	1,514	4	4	3	5	4
450	1,703	5	5	3	5	4
500	1,892	5	5	3	5	5

				Minimum Pipe Sizes (Nominal)		
Pump Rating		Suction[1, 2] (in.)	Discharge[1] (in.)	Relief Valve (in.)	Relief Valve Discharge (in.)	Meter I (in.
gpm	L/min					
750	2,839	6	6	4	6	5
1,000	3,785	8	6	4	8	6
1,250	4,731	8	8	6	8	6
1,500	5,677	8	8	6	8	8
2,000	7,570	10	10	6	10	8
2,500	9,462	10	10	6	10	8
3,000	11,355	12	12	8	12	8
3,500	13,247	12	12	8	12	10
4,000	15,140	14	12	8	14	10
4,500	17,032	16	14	8	14	10
5,000	18,925	16	14	8	14	10

1 Actual diameter of pump flange is permitted to be different from pipe diameter.
2 Applies only to that portion of suction pipe specified in 2-9.3.

Chapter 3 Centrifugal Pumps

3-1 General.

3-1.1* Types.

Centrifugal pumps shall be of the overhung impeller between bearings design. The overhung impeller design shall be close coupled or separately coupled single- or two-stage end suction-type *[see Figures A-3-1.1(a) and (b)]* or in-line-type *[see Figures A-3-1.1(c), (d), and (e)]* pumps. The impeller between bearings design shall be separately coupled single-stage or multistage axial (horizontal) split-case-type *[see Figure A-3-1.1(f)]* or radial (vertical) split-case-type *[see Figure A-3-1.1(g)]* pumps.

3-1.2* Application.

Centrifugal pumps shall not be used where a static suction lift is required.

3-2* Factory and Field Performance.

Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shutoff head shall not exceed 140 percent of rated head for any type pump. *(See Figure A-3-2.)*

3-3 Fittings.

3-3.1*

Where necessary, the following fittings for the pump shall be provided by the pump manufacturer or an authorized representative *(see Figure A-3-3.1):*

(1) Automatic air release valve

(2) Circulation relief valve

(3) Pressure gauges

3-3.2

Where necessary, the following fittings shall be provided *(see Figure A-3-3.1):*

(1) Eccentric tapered reducer at suction inlet

(2) Hose valve manifold with hose valves

(3) Flow-measuring device

(4) Relief valve and discharge cone

(5) Pipeline strainer

3-3.3 Automatic Air Release.

Pumps that are automatically controlled shall be provided with a listed float-operated air release valve having $^{1}/_{2}$ in. (12.7 mm) minimum diameter discharged to atmosphere.

Exception: Overhung impeller-type pumps with top centerline discharge or vertically mounted to naturally vent the air.

3-3.4 Pipeline Strainer.

Pumps that require removal of the driver to remove rocks or debris from the pump impeller shall have a pipeline strainer installed in the suction line a minimum of 10 pipe diameters from the suction flange. The pipeline strainer shall be cast or heavy fabricated with corrosion-resistant metallic removable screens to permit cleaning of strainer element without removing driver from pump. The strainer screens shall have a free area of at least four times the area of the suction connections and the openings shall be sized to restrict the passage of a $^{5}/_{16}$-in. (7.9-mm) sphere.

3-4 Foundation and Setting.

3-4.1*

Overhung impeller and impeller between bearing design pumps and driver shall be mounted on a common grouted base plate.

Exception: Pumps of the overhung impeller close couple in-line [see Figure A-3-1.1(c)] shall be permitted to be mounted on a base attached to the pump mounting base plate.

3-4.2

The base plate shall be securely attached to a solid foundation in such a way that proper pump and driver shaft alignment will be ensured.

3-4.3*

The foundation shall be sufficiently substantial to form a permanent and rigid support for the base plate.

3-4.4

The base plate, with pump and driver mounted on it, shall be set level on the foundation.

3-5* Connection to Driver and Alignment.

3-5.1

The pump and driver on separately coupled-type pumps shall be connected by a rigid coupling, flexible coupling, or flexible connecting shaft. All coupling types shall be listed for this service.

3-5.2

Pumps and drivers on separately coupled-type pumps shall be aligned in accordance with the coupling and pump manufacturers' specifications and the *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. *(See A-3-5.)*

Chapter 4 Vertical Shaft Turbine-Type Pumps

4-1* General.

4-1.1* Suitability.

Where the water supply is located below the discharge flange centerline and the water supply pressure is insufficient for getting the water to the fire pump, a vertical shaft turbine-type pump shall be used.

4-1.2 Characteristics.

Pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. The total shutoff head shall not exceed 140 percent of the total rated head on vertical turbine pumps. *(See Figure A-3-2.)*

4-2 Water Supply.

4-2.1 Source.

4-2.1.1*

The water supply shall be adequate, dependable, and acceptable to the authority having jurisdiction.

4-2.1.2*

The acceptance of a well as a water supply source shall be dependent upon satisfactory development of the well and establishment of satisfactory aquifer characteristics. *(See Section 1-8 for definitions.)*

4-2.2 Pump Submergence.

4-2.2.1* Well Installations.

Proper submergence of the pump bowls shall be provided for reliable operation of the fire pump unit. Submergence of the second impeller from the bottom of the pump bowl assembly shall be not less than 10 ft (3 m) below the pumping water level at 150 percent of rated capacity. *(See Figure A-4-2.2.1.)* The submergence shall be increased by 1 ft (0.3 m) for each 1000 ft (305 m) of elevation above sea level.

4-2.2.2* Wet Pit Installations.

To provide submergence for priming, the elevation of the second impeller from the bottom of the pump bowl assembly shall be such that it is below the lowest pumping water level in the open body of water supplying the pit. For pumps with rated capacities of 2000 gpm (7570 L/min) or greater, additional submergence is required to prevent the formation of vortices and to provide required net positive suction head (NPSH) in order to prevent excessive cavitation. The required submergence shall be obtained from the pump manufacturer.

4-2.3 Well Construction.

4-2.3.1

It shall be the responsibility of the groundwater supply contractor to perform the necessary groundwater investigation to establish the reliability of the supply, to develop a well to produce the required supply, and to perform all work and install all equipment in a thorough and workmanlike manner.

4-2.3.2

The vertical turbine-type pump is designed to operate in a vertical position with all parts in correct alignment. The well therefore shall be of ample diameter and sufficiently plumb to receive the pump.

4-2.4 Unconsolidated Formations (Sands and Gravels).

4-2.4.1

All casings shall be of steel of such diameter and installed to such depths as the formation could justify and as best meet the conditions. Both inner and outer casings shall have a minimum wall thickness of 0.375 in. (9.5 mm). Inner casing diameter shall be not less than 2 in. (51 mm) larger than the pump bowls.

4-2.4.2

The outer casing shall extend down to approximately the top of the water-bearing formation. The inner casing of lesser diameter and the well screen shall extend as far into the formation as the water-bearing stratum could justify and as best meets the conditions.

4-2.4.3

The well screen is a vital part of the construction and careful attention shall be given to its selection. It shall be the same diameter as the inner casing and of the proper length and percent open area to provide an entrance velocity not exceeding 0.15 ft/sec (46 mm/sec). The screen shall be made of a corrosion- and acid-resistant material, such as stainless steel or monel. Monel shall be used where it is anticipated that the chloride content of the well water will exceed 1000 parts per million. The screen shall have adequate strength to resist the external forces that will be applied after it is installed and to minimize the likelihood of damage during the installation.

4-2.4.4

The bottom of the well screen shall be sealed properly with a plate of the same material as the screen. The sides of the outer casing shall be sealed by the introduction of neat cement placed under pressure from the bottom to the top. Cement shall be allowed to set for a minimum of 48 hours before drilling operations are continued.

4-2.4.5

The immediate area surrounding the well screen not less than 6 in. (152 mm) shall be filled with clean and well-rounded gravel. This gravel shall be of such size and quality as will create a gravel filter to ensure sand-free production and a low velocity of water leaving the formation and entering the well.

4-2.4.6

Wells for fire pumps not exceeding 450 gpm (1703 L/min) developed in unconsolidated formations without an artificial gravel pack, such as tubular wells, shall be acceptable sources of water supply for fire pumps not exceeding 450 gpm (1703 L/min). They shall comply with all of the requirements of 4-2.3 and all of 4-2.4, except 4-2.4.4 and 4-2.4.5.

4-2.5* Consolidated Formations.

Where the drilling penetrates unconsolidated formations above the rock, surface casing shall be installed, seated in solid rock, and cemented in place.

4-2.6 Developing a Well.

Developing a new well and cleaning it of sand or rock particles (not to exceed five parts per million) shall be the responsibility of the groundwater supply contractor. Such development shall be performed with a test pump and not a fire pump. Freedom from sand shall be determined when the test pump is operated at 150 percent of rated capacity of the fire pump for which the well is being prepared.

4-2.7* Test and Inspection of Well.

A test to determine the water production of the well shall be made. An acceptable water measuring device such as an orifice, a venturi meter, or a calibrated Pitot tube shall be used. The test shall be witnessed by a representative of the customer, contractor, and authority having jurisdiction, as required. It shall be continuous for a period of at least 8 hours at 150 percent of the rated capacity of the fire pump with 15-minute interval readings over the period of the test. The test shall be evaluated with consideration given to the effect of other wells in the vicinity and any possible seasonal variation in the water table at the well site. Test data shall describe the static water level and the pumping water level at 100 percent and 150 percent, respectively, of the rated capacity of the fire pump for which the well is being prepared. All existing wells within a 1000-ft (305-m) radius of the fire well shall be monitored throughout the test period.

4-3 Pump.

4-3.1* Vertical Turbine Pump Head Component.

The pump head shall be either the aboveground or belowground discharge type. It shall be designed to support the driver, pump, column assembly, bowl assembly, maximum down thrust, and the oil tube tension nut or packing container.

4-3.2 Column.

4-3.2.1

The pump column shall be furnished in sections not exceeding a nominal length of 10 ft (3 m), shall be not less than the weight specified in Table 4-3.2.1, and shall be connected by threaded-sleeve couplings or flanges. The ends of each section of threaded pipe shall be faced parallel and machined with threads to permit the ends to butt so as to form accurate alignment of the pump column. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment.

Table 4-3.2.1 Pump Column Pipe Weights

Nominal Size (Inside Diameter) (in.)	Outside Diameter (O.D.)		Weight per ft (Plain Ends) (lb*)
	in.	mm	
6	6.625	168.3	18.97
7	7.625	193.7	22.26
8	8.625	219.1	24.70
9	9.625	244.5	28.33
10	10.75	273.0	31.20
12	12.75	323.8	43.77

Nominal Size (Inside Diameter) (in.)	Outside Diameter (O.D.)		Weight per ft (Plain Ends) (lb*)
	in.	mm	
14 O.D.	14.00	355.6	53.57

* Metric weights in kilograms per meter — 28.230, 33.126, 36.758, 42.159, 46.431, 65.137, and 81.209.

4-3.2.2

Where the static water level exceeds 50 ft (15 m) below ground, oil-lubricated-type pumps shall be used. *(See Figure A-4-1.1.)*

4-3.2.3

Where the pump is of the enclosed line shaft oil-lubricated type, the shaft-enclosing tube shall be furnished in interchangeable sections not over 10 ft (3 m) in length of extra-strong pipe. An automatic sight feed oiler shall be provided on a suitable mounting bracket with connection to the shaft tube for oil-lubricated pumps. *(See Figure A-4-1.1.)*

4-3.2.4

The pump line shafting shall be sized so critical speed shall be 25 percent above and below the operating speed of the pump. Operating speed shall include all speeds from shutoff to the 150 percent point of the pump, which vary on engine drives.

4-3.3 Bowl Assembly.

4-3.3.1

The pump bowl shall be of close-grained cast iron, bronze, or other suitable material in accordance with the chemical analysis of the water and experience in the area.

4-3.3.2

Impellers shall be of the enclosed type and shall be of bronze or other suitable material in accordance with the chemical analysis of the water and experience in the area.

4-3.4 Suction Strainer.

4-3.4.1

A cast or heavy fabricated, corrosion-resistant metal cone or basket-type strainer shall be attached to the suction manifold of the pump. The suction strainer shall have a free area of at least four times the area of the suction connections and the openings shall be sized to restrict the passage of a $^1/_2$-in. (12.7-mm) sphere.

4-3.4.2

For installations in a wet pit, this suction strainer shall be required in addition to the intake screen. *(See Figure A-4-2.2.2.)*

4-3.5 Fittings.

4-3.5.1

The following fittings shall be required for attachment to the pump:

(1) Automatic air release valve as specified in 4-3.5.2

(2) Water level detector as specified in 4-3.5.3

(3) Discharge pressure gauge as specified in 2-5.1

(4) Relief valve and discharge cone where required by 2-13.1

(5) Hose valve header and hose valves as specified in 2-14.3 or metering devices as specified in 2-14.2

4-3.5.2

A $1^1/_2$-in. (38.1-mm) pipe size or larger automatic air release valve shall be provided to vent air from the column and the discharge head upon the starting of the pump. This valve shall also admit air to the column to dissipate the vacuum upon stopping of the pump. It shall be located at the highest point in the discharge line between the fire pump and the discharge check valve.

4-3.5.3*

Each well installation shall be equipped with a suitable water level detector. If an air line is used, it shall be brass, copper, or series 300 stainless steel. Air lines shall be strapped to column pipe at 10-ft (3-m) intervals.

4-4* Installation.

4-4.1 Pump House.

The pump house shall be of such design as will offer the least obstruction to the convenient handling and hoisting of vertical pump parts. The requirements of Sections 2-8 and 8-3 shall also apply.

4-4.2 Outdoor Setting.

If in special cases the authority having jurisdiction does not require a pump room and the unit is installed outdoors, the driver shall be screened or enclosed and adequately protected against tampering. The screen or enclosure shall be easily removable and shall have provision for ample ventilation.

4-4.3 Foundation.

4-4.3.1

Certified dimension prints shall be obtained from the manufacturer.

4-4.3.2

The foundation for vertical pumps shall be substantially built to carry the entire weight of the pump and driver plus the weight of the water contained in it. Foundation bolts shall be provided to firmly anchor the pump to the foundation.

4-4.3.3

The foundation shall be of sufficient area and strength that the load per square inch (millimeter) on concrete does not exceed design standards.

4-4.3.4

The top of the foundation shall be carefully leveled to permit the pump to hang freely over a well pit on a short-coupled pump. On a well pump the pump head shall be positioned plumb over the well, which is not necessarily level.

4-4.3.5

Where the pump is mounted over a sump or pit, I beams shall be permitted to be used. Where a right-angle gear is used, the driver shall be installed parallel to the beams.

4-5 Driver.

4-5.1 Method of Drive.

4-5.1.1

The driver provided shall be so constructed that the total thrust of the pump, which includes the weight of the shaft, impellers, and hydraulic thrust, can be carried on a thrust bearing of ample capacity so that it will have an average life rating of 5 years continuous operation. All drivers shall be so constructed that axial adjustment of impellers can be made to permit proper installation and operation of the equipment. The pump shall be driven by a vertical hollow-shaft electric motor or vertical hollow-shaft right-angle gear drive with diesel engine or steam turbine.

Exception: Diesel engines and steam turbines designed and listed for vertical installation with vertical shaft turbine-type pumps are permitted to employ solid shafts and do not require a right-angle gear drive but do require a nonreverse ratchet.

4-5.1.2

Motors shall be of the vertical hollow-shaft type and comply with 6-5.1.5.

4-5.1.3 Gear Drives.

4-5.1.3.1

Gear drives and flexible connecting shafts shall be acceptable to the authority having jurisdiction. They shall be of the vertical hollow-shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment. The gear drive shall be equipped with a nonreverse ratchet.

4-5.1.3.2

All gear drives shall be listed and rated by the manufacturer at a load equal to the maximum horsepower and thrust of the pump for which the gear drive is intended.

4-5.1.3.3

Water-cooled gear drives shall be equipped with a visual means to determine whether water circulation is occurring.

4-5.1.4

The flexible connecting shaft shall be listed for this service. The operating angle for the flexible connecting shaft shall not exceed the limits as required by the manufacturer for the speed and horsepower transmitted.

4-5.2 Controls.

The controllers for the motor, diesel engine, or steam turbine shall comply with specifications for either electric-drive controllers in Chapter 7 or engine-drive controllers in Chapter 9.

4-5.3 Driver.

Each vertical shaft turbine-type fire pump shall have its own dedicated driver, and each driver shall have its own dedicated controller.

4-6 Operation and Maintenance.

4-6.1 Operation.

4-6.1.1*

Before the unit is started for the first time after installation, all field-installed electrical connections and discharge piping from the pump shall be checked. With the top drive coupling removed, the drive shaft shall be centered in the top drive coupling for proper alignment and the motor shall be operated momentarily to ensure that it rotates in the proper direction. With the top drive coupling reinstalled, the impellers shall be set for proper clearance according to the manufacturer’s instructions.

4-6.1.2*

With the precautions of 4-6.1.1 taken, the pump shall be started and allowed to run. The operation shall be observed for vibration while running, with vibration limits according to the *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. The driver shall be observed for proper operation.

4-6.2 Maintenance.

4-6.2.1

The manufacturer's instructions shall be carefully followed in making repairs and dismantling and reassembling pumps.

4-6.2.2

When spare or replacement parts are ordered, the pump serial number stamped on the nameplate fastened to the pump head shall be included in order to make sure the proper parts are provided.

4-6.2.3

Ample head room and access for removal of pump shall be maintained.

Chapter 5 Positive Displacement Pumps

5-1* General.

5-1.1 Types.

Positive displacement pumps shall be as defined in Section 1-8.

5-1.2* Suitability.

5-1.2.1

The positive displacement-type pump shall be listed for the intended application.

5-1.2.2*

The listing shall verify the characteristic performance curves for a given pump model.

5-1.3 Application.

Positive displacement pumps are used for pumping water, foam concentrates, or additives. The liquid viscosity will impact pump selection.

5-1.4 Pump Seals.

The seal type acceptable for positive displacement pumps shall be either mechanical or lip seal. Packing shall not be used.

5-1.5* Pump Materials.

Materials used in pump construction shall be selected based on the corrosion potential of the environment, fluids used, and operational conditions. *(See the definition in Section 1-8 for corrosion-resistant materials.)*

5-2 Foam Concentrate and Additive Pumps.

5-2.1

Additive pumps shall meet the requirements for foam concentrate pumps.

5-2.2*

Net positive suction head (NPSH) shall exceed the pump manufacturer's required NPSH plus 5 ft (1.52 m) of liquid.

5-2.2.1

Seal materials shall be compatible with the foam concentrate or additive.

5-2.2.2

Foam concentrate pumps shall be capable of dry running for 10 minutes without damage.

5-2.3*

Pumps shall have foam concentrate flow rates to meet the maximum foam flow demand for their intended service.

5-2.4*

The discharge pressure of the pump shall exceed the maximum water pressure under any operating condition at the point of foam concentrate injection.

5-3 Water Mist System Pumps.

5-3.1*

Positive displacement pumps for water shall have adequate capacities to meet the maximum system demand for their intended service.

5-3.2

NPSH shall exceed the pump manufacturer's required NPSH plus 5 ft (1.52 m) of liquid. The inlet pressure to the pump shall not exceed the pump manufacturer's recommended maximum inlet pressure.

5-3.3

When the pump output has the potential to exceed the system flow requirements, a means to relieve the excess flow such as an unloader valve or orifice shall be provided. Where the pump is equipped with an unloader valve, it shall be in addition to the safety relief valve as outlined in 5-4.2.

5-4 Fittings.

5-4.1

A compound suction gauge and a discharge pressure gauge shall be furnished.

5-4.2*

All pumps shall be equipped with a listed safety relief valve capable of relieving 100 percent of the pump capacity. The pressure relief valve shall be set at or below the lowest rated pressure of any component. The relief valve shall be installed on the pump discharge to prevent damage to the fire protection system.

5-4.3*

For foam concentrate pumps, safety relief valves shall be piped to return the valve discharge to the concentrate supply tank. Valves installed on the discharge side of a safety relief valve shall be supervised open.

5-4.4*

For positive displacement water mist pumps, safety relief valves shall discharge to a drain or to the water supply or pump suction. A means of preventing overheating shall be provided when the relief valve is plumbed to discharge to the pump suction.

5-4.5*

Pumps shall be equipped with a removable and cleanable suction strainer installed at least 10 pipe diameters from the pump suction inlet. Suction strainer pressure drop shall be calculated to ensure that sufficient NPSH is available to the pump. The net open area of the strainer shall be at least four times the area of the suction piping. Strainer mesh size shall be in accordance with the pump manufacturer's recommendation.

5-4.6

Design of the system shall include protection of potable water supplies and prevent cross connection or contamination.

5-5 Pump Drivers.

5-5.1*

The driver shall be sized for and have enough power to operate the pump and drive train at all design points.

5-5.2

If a reduction gear is provided between the driver and the pump, it shall be listed for the intended use. Reduction gears shall meet the requirements of AGMA 390.03, *Handbook for*

Helical and Master Gears. Gears shall be AGMA Class 7 or better and pinions shall be AGMA Class 8 or better. Bearings shall be in accordance with ABMA standards and applied for an L10 life of 15,000 hours.

5-6* Controllers.

See Chapters 7 and 9 for requirements for controllers.

5-7 Foundation and Setting.

5-7.1

The pump and driver shall be mounted on a common grouted base plate.

5-7.2

The base plate shall be securely attached to a solid foundation in such a way that proper pump and driver shaft alignment will be maintained. The foundation shall provide a solid support for the base plate.

5-8 Driver Connection and Alignment.

5-8.1

The pump and driver shall be connected by a listed, closed-coupled, flexible coupling or timing gear type of belt drive coupling. The coupling shall be selected to ensure that it is capable of transmitting the horsepower of the driver and does not exceed the manufacturer’s maximum recommended horsepower and speed.

5-8.2

Pumps and drivers shall be aligned once final base plate placement is complete. Alignment shall be in accordance with the coupling manufacturer’s specifications. The operating angle for the flexible coupling shall not exceed the recommended tolerances.

Chapter 6 Electric Drive for Pumps

6-1 General.

This chapter covers the minimum performance and testing requirements of the sources and transmission of electrical power to motors driving fire pumps. Also covered are the minimum performance requirements of all intermediate equipment between the source(s) and the pump, including the motor(s), excepting the electric fire pump controller, transfer switch, and accessories *(see Chapter 7)*. All electrical equipment and installation methods shall comply with NFPA 70, *National Electrical Code*, Article 695, and other applicable articles.

6-2 Power Source(s).

Power shall be supplied to the electric motor-driven fire pump by a reliable source or two or more approved independent sources, all of which shall make compliance with Section 6-4 possible.

Exception: Where electric motors are used and the height of the structure is beyond the pumping capacity of the fire department apparatus, a second source in accordance with 6-2.3 shall be provided.

6-2.1 Service.

Where power is supplied by a service, it shall be located and arranged to minimize the possibility of damage by fire from within the premises and exposing hazards.

6-2.2* On-Site Electrical Power Production Facility.

Where power is supplied to the fire pump(s) solely by an on-site electrical power production facility, such facility shall be located and protected to minimize the possibility of damage by fire.

6-2.3* Other Sources.

For pump(s) driven by electric motor(s) where reliable power cannot be obtained from one of the power sources of 6-2.1 or 6-2.2, one more of the following shall also be provided:

(1) An approved combination of two or more of the power sources in Section 6-2

(2) One of the approved power sources and an on-site standby generator *(see 6-2.4.2)*

(3) An approved combination of feeders constituting two or more power sources, but only as permitted in 6-2.4.3

(4) An approved combination of one or more feeders in combination with an on-site standby generator, but only as permitted in 6-2.4.3

(5) A redundant diesel engine-driven fire pump complying with Chapter 8

(6) A redundant steam turbine-driven fire pump complying with Chapter 10

6-2.4 Multiple Power Sources to Electric Motor-Driven Fire Pumps.

6-2.4.1 Arrangement of Multiple Power Sources.

Where multiple electric power sources are provided, they shall be arranged so that a fire, structural failure, or operational accident that interrupts one source will not cause an interruption of the other source.

6-2.4.2 On-Site Generator.

Where alternate power is supplied by an on-site generator, the generator shall be located and protected in accordance with 6-2.1 and Section 6-6.

6-2.4.3 Feeder Sources.

This requirement shall apply to multi-building campus-style complexes with fire pumps at one or more buildings. Where sources in 6-2.1 and 6-2.2 are not practicable, with the approval of the authority having jurisdiction, two or more feeder sources shall be permitted as one power source or as more than one power source where such feeders are connected to or derived from separate utility services. The connection(s), overcurrent protective device(s), and disconnecting means for such feeders shall meet the requirements of 6-3.2.2.2 and 6-3.2.2.3.

6-2.4.4 Supply Conductors.

Supply conductors shall directly connect the power sources to either a listed combination fire pump controller and power transfer switch or to a disconnecting means and overcurrent protective device(s) meeting the requirements of 6-3.2.2.2 and 6-3.2.2.3.

6-3* Power Supply Lines.

6-3.1* Circuit Conductors.

Circuits feeding fire pump(s) and their accessories shall be dedicated and protected to resist possible damage by fire, structural failure, or operational accident.

6-3.2 Power Supply Arrangement.

6-3.2.1 Power Supply Connection.

The power supply to the fire pump shall not be disconnected when the plant power is disconnected.

Exception: Where the installation is approved in accordance with 6-2.4.3, the disconnection of plant power to the fire pumps shall be permitted under circumstances that automatically ensure the continued availability of an alternate power supply.

6-3.2.2 Continuity of Power.

Circuits that supply electric motor-driven fire pumps shall be supervised from inadvertent disconnection as covered in 6-3.2.2.1 or 6-3.2.2.2 and 6-3.2.2.3.

6-3.2.2.1* Direct Connection.

The supply conductors shall directly connect the power source to either a listed fire pump controller or listed combination fire pump controller and power transfer switch.

6-3.2.2.2 Supervised Connection.

A single disconnecting means and associated overcurrent protective device(s) shall be permitted to be installed between a remote power source and one of the following:

(1) A listed fire pump controller

(2) A listed fire pump power transfer switch

(3) A listed combination fire pump controller and power transfer switch

6-3.2.2.3 Disconnecting Means and Overcurrent Protective Devices.

For systems installed under the provisions of 6-2.4.3 only, such additional disconnecting means and associated overcurrent protective device(s) shall be permitted as required to comply with provisions of NFPA 70, *National Electrical Code*. All disconnecting means and overcurrent protective device(s) that are unique to the fire pump loads shall comply with all of the following.

(a) *Overcurrent Protective Device Selection.* The overcurrent protective device(s) shall be selected or set to carry indefinitely the sum of the locked rotor current of the fire pump motor(s), the pressure maintenance pump motor(s), and the full-load current of the associated fire pump accessory equipment when connected to this power supply.

(b) *Disconnecting Means.* The disconnecting means shall be as follows:

(1) Identified as suitable for use as service equipment

(2) Lockable in the closed position

(3) Located sufficiently remote from other building or other fire pump source disconnecting means that inadvertent contemporaneous operation would be unlikely

(c) *Disconnect Marking.* The disconnecting shall be permanently marked “Fire Pump Disconnecting Means.” The letters shall be at least 1 in. (25.4 mm) in height and they shall be visible without opening enclosure doors or covers.

(d) *Controller Marking.* A placard shall be placed adjacent to the fire pump controller stating the location of this disconnecting means and the location of the key (if the disconnecting means is locked).

(e) *Supervision.* The disconnecting means shall be supervised in the closed position by one of the following methods:

(1) Central station, proprietary, or remote station signal device

(2) Local signaling service that will cause the sounding of an audible signal at a constantly attended location

(3) Locking of the disconnecting means in the closed position

(4) Sealing of disconnecting means and approved weekly recorded inspections where the disconnecting means are located within fenced enclosures or in buildings under the control of the owner

6-3.2.2.4 Short Circuit Coordination.

For systems installed under the provisions of 6-2.4.3 only, and where more than one disconnecting means is supplied by a single feeder, the overcurrent protective device(s) in each disconnecting means shall be selectively coordinated with any other supply side overcurrent protective device(s).

6-3.2.2.5 Transformers.

Where the supply voltage is different from the utilization voltage of the fire pump motor, a transformer meeting the requirements of Article 695-5 of NFPA 70, *National Electrical Code*, and a disconnecting means and overcurrent protective device(s) meeting the requirements of 6-3.2.2.2 shall be installed.

6-4* Voltage Drop.

The voltage at the controller line terminals shall not drop more than 15 percent below normal (controller-rated voltage) under motor-starting conditions. The voltage at the motor terminals shall not drop more than 5 percent below the voltage rating of the motor when the motor is operating at 115 percent of the full-load current rating of the motor.

Exception: This starting limitation shall not apply for emergency-run mechanical starting. (See 7-5.3.2.)

6-5 Motors.

6-5.1 General.

6-5.1.1

All motors shall comply with NEMA MG-1, *Motors and Generators*, shall be marked as complying with NEMA Design B standards, and shall be specifically listed for fire pump service. *(See Table 6-5.1.1.)*

6-5.1.1.1*

The corresponding values of locked rotor current for motors rated at other voltages shall be determined by multiplying the values shown by the ratio of 460 V to the rated voltage in Table 6-5.1.1.

6-5.1.1.2

Code letters of motors for all other voltages shall conform with those shown for 460 V in Table 6-5.1.1.

6-5.1.2

All motors shall comply with NEMA MG-1, *Motors and Generators*, and shall be marked as complying with NEMA Design B standards.

Exception: Direct-current, high-voltage (over 600 V), large-horsepower (over 500 horsepower), single-phase, universal-type, or wound-rotor motors shall be permitted to be used where approved.

6-5.1.3

All motors shall be rated for continuous duty.

6-5.1.4

Electric motor-induced transients shall be coordinated with the provisions of 7-4.3.3 to prevent nuisance tripping of motor controller protective devices.

6-5.1.5

Motors for vertical shaft turbine-type pumps shall be dripproof, squirrel cage induction type. The motor shall be equipped with a nonreverse ratchet.

Table 6-5.1.1 Horsepower and Locked Rotor Current Motor Designation for NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 460 V (Ampere)	Motor Designation (*NEC*, Locked Rotor Indicating Code Letter) "F" To and Including
5	46	J
$7^1/_2$	64	H
10	81	H
15	116	G
20	145	G
25	183	G
30	217	G
40	290	G
50	362	G
60	435	G
75	543	G
100	725	G
125	908	G
150	1085	G
200	1450	G
250	1825	G
300	2200	G
350	2550	G
400	2900	G
450	3250	G
500	3625	G

6-5.2 Current Limits.

6-5.2.1

The motor capacity in horsepower shall be such that the maximum motor current in any phase under any condition of pump load and voltage unbalance shall not exceed the motor-rated full-load current multiplied by the service factor. The maximum service factor at which a motor shall be used is 1.15. These service factors shall be in accordance with NEMA MG-1, *Motors and Generators*.

Exception: General-purpose (open and dripproof) motors, totally enclosed fan-cooled (TEFC) motors, and totally enclosed nonventilated (TENV) motors shall not have a service factor larger than 1.15.

6-5.2.2

Motors used at altitudes above 3300 ft (1000 m) shall be operated or derated according to NEMA MG-1, *Motors and Generators*, Part 14.

6-5.3 Marking.

6-5.3.1

Marking of motor terminals shall be in accordance with NEMA MG-1, *Motors and Generators*, Part 2.

6-5.3.2

A motor terminal connecting diagram for multiple lead motors shall be furnished by the motor manufacturer.

6-6 On-Site Power Generator Systems.

6-6.1

Where on-site generator systems are used to supply power to fire pump motors to meet the requirements of 6-2.3, they shall be of sufficient capacity to allow normal starting and running of the motor(s) driving the fire pump(s) while supplying all other simultaneously operated load(s). A tap ahead of the on-site generator disconnecting means shall not be required.

6-6.2*

These power sources shall comply with Section 6-4 and shall meet the requirements of Level 1, Type 10, Class X systems of NFPA 110, *Standard for Emergency and Standby Power Systems*. The fuel supply capacity shall be sufficient to provide 8 hours of fire pump operation at 100 percent of the rated pump capacity in addition to the supply required for other demands.

6-6.3

Automatic sequencing of the fire pumps shall be permitted in accordance with 7-5.2.4.

6-6.4

Transfer of power to the fire pump controller between the normal supply and one alternate supply shall take place within the pump room.

6-6.5

Where protective devices are installed in the on-site power source circuits at the generator, such devices shall allow instantaneous pickup of the full pump room load.

Chapter 7 Electric-Drive Controllers and Accessories

7-1 General.

7-1.1 Application.

This chapter covers the minimum performance and testing requirements for controllers and transfer switches for electric motors driving fire pumps. Accessory devices, including alarm monitoring and signaling means, are included where necessary to ensure the minimum performance of the aforementioned equipment.

7-1.2 Performance and Testing.

7-1.2.1

All controllers and transfer switches shall be specifically listed for electric motor-driven fire pump service.

7-1.2.2*

The controller and transfer switch shall be suitable for the available short-circuit current at the line terminals of the controller and transfer switch and shall be marked "Suitable for use on a circuit capable of delivering not more than ____ amperes RMS symmetrical at ____ volts ac." The blank spaces shown shall have appropriate numbers filled in for each installation.

7-1.2.3

All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

7-1.2.4

All controllers and transfer switches shall be listed as "suitable for use as service equipment" where so used.

7-1.2.5

All controllers shall be marked "Electric Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete electrical rating. Where multiple pumps serve different areas or portions of the facility, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

7-1.2.6

It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a manufacturer's representative when needed for service and adjustment of the equipment during the installation, testing, and warranty periods.

7-2 Location.

7-2.1*

Controllers shall be located as close as is practical to the motors they control and shall be within sight of the motors.

7-2.2

Controllers shall be located or protected so that they will not be injured by water escaping from pumps or pump connections. Current-carrying parts of controllers shall be not less than 12 in. (305 mm) above the floor level.

7-2.3

Working clearances around controllers shall comply with NFPA 70, *National Electrical Code,* Article 110.

7-3 Construction.

7-3.1 Equipment.

All equipment shall be suitable for use in locations subject to a moderate degree of moisture, such as a damp basement.

7-3.2 Mounting.

All equipment shall be mounted in a substantial manner on a single noncombustible supporting structure.

7-3.3 Enclosures.

7-3.3.1*

The structure or panel shall be securely mounted in, as a minimum, a National Electrical Manufacturers Association (NEMA) Type 2, dripproof enclosure(s). Where the equipment is located outside or special environments exist, suitably rated enclosures shall be used.

7-3.3.2

The enclosure(s) shall be grounded in accordance with NFPA 70, *National Electrical Code,* Article 250.

7-3.4 Connections and Wiring.

7-3.4.1

All busbars and connections shall be readily accessible for maintenance work after installation of the controller. These connections shall be arranged so that disconnection of the external circuit conductors will not be required.

7-3.4.2

Provisions shall be made within the controller to permit the use of test instruments for measuring all line voltages and currents without disconnecting any conductors within the controller. Means shall be provided on the exterior of the controller to read all line currents and all line voltages.

7-3.4.3

Busbars and other wiring elements of the controller shall be designed on a continuous-duty basis.

Exception: Conductors that are in a circuit only during the motor-starting period shall be permitted to be designed accordingly.

7-3.4.4

A fire pump controller shall not be used as a junction box to supply other equipment. Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the fire pump controller.

7-3.5 Protection of Auxiliary Circuits.

Circuits that are necessary for proper operation of the controller shall not have overcurrent protective devices connected in them.

7-3.6* External Operation.

All switching equipment for manual use in connecting or disconnecting, or starting or stopping, the motor shall be externally operable.

7-3.7 Electrical Diagrams and Instructions.

7-3.7.1

An electrical schematic diagram shall be provided and permanently attached to the inside of the controller enclosure.

7-3.7.2

All the field wiring terminals shall be plainly marked to correspond with the field connection diagram furnished.

7-3.7.3*

Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

7-3.8 Marking.

Each motor control device and each switch and circuit breaker shall be marked to plainly indicate the name of the manufacturer, the designated identifying number, and the electrical rating in volts, horsepower, amperes, frequency, phases, and so forth, as appropriate. The markings shall be so located as to be visible after installation.

7-4 Components.

7-4.1* Voltage Surge Arrester.

A voltage surge arrester complying with ANSI/IEEE C62.1, *IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits,* or C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits,* shall be installed from each phase to ground. *(See 7-3.2.)* The surge arrester shall be rated to suppress voltage surges above line voltage.

Exception No. 1: These voltage surge arresters shall not be mandatory for controllers rated in excess of 600 V. (See Section 7-6.)

Exception No. 2: These voltage surge arresters shall not be mandatory if the controller can withstand without damage a 10-kV impulse in accordance with ANSI/IEEE C62.41, Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits.

7-4.2 Isolating Switch.

7-4.2.1

The isolating switch shall be a manually operable motor circuit switch or a molded case switch having a horsepower rating equal to or greater than the motor horsepower.

Exception No. 1: A molded case switch having an ampere rating not less than 115 percent of the motor rated full-load current and also suitable for interrupting the motor locked rotor current shall be permitted.*

Exception No. 2: A molded case isolating switch shall be permitted to have self-protecting instantaneous short-circuit overcurrent protection, provided that this switch does not trip unless the circuit breaker in the same controller trips.

7-4.2.2

The isolating switch shall be externally operable.

7-4.2.3*

The ampere rating of the isolating switch shall be at least 115 percent of the full-load current rating of the motor.

7-4.2.4

The following warning shall appear on or immediately adjacent to the isolating switch:

W A R N I N G
DO NOT OPEN OR CLOSE THIS SWITCH WHILE THE CIRCUIT BREAKER (DISCONNECTING MEANS) IS IN CLOSED POSITION.

Exception: Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can neither be opened nor closed while the circuit breaker is closed, the warning label shall be permitted to be replaced with an instruction label that directs the order of operation. This label shall be permitted to be part of the label required by 7-3.7.3.

7-4.2.5

The isolating switch operating handle shall be provided with a spring latch that shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit opening or closing of the switch.

Exception: Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can neither be opened nor closed while the circuit breaker is closed, this latch shall not be required.

7-4.3 Circuit Breaker (Disconnecting Means).

7-4.3.1*

The motor branch circuit shall be protected by a circuit breaker that shall be connected directly to the load side of the isolating switch and shall have one pole for each ungrounded circuit conductor.

Exception: Where the motor branch circuit is transferred to an alternate source supplied by an on-site generator and is protected by an overcurrent device at the generator (see 6-6.5), the locked rotor overcurrent protection within the fire pump controller shall be permitted to be bypassed when that motor branch circuit is so connected.

7-4.3.2

The circuit breaker shall have the following mechanical characteristics.

(1) It shall be externally operable *(see 7-3.6).*

(2) It shall trip free of the handle.

(3) A nameplate with the legend “Circuit breaker — disconnecting means” in letters not less than $^3/_8$ in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for operating the circuit breaker.

7-4.3.3*

The circuit breaker shall have the following electrical characteristics:

(1) A continuous current rating not less than 115 percent of the rated full-load current of the motor

(2) Overcurrent-sensing elements of the nonthermal type

(3) Instantaneous short-circuit overcurrent protection

(4) * An adequate interrupting rating to provide the suitability rating *(see 7-1.1.2)* of the controller

(5) Capability of allowing normal and emergency *(see 7-5.3.2)* starting and running of the motor without tripping

(6) An instantaneous trip setting of not more than 20 times the full-load current

Exception: Current limiters, where integral parts of the circuit breaker, shall be permitted to be used to obtain the required interrupting rating, provided all of the following requirements are met.*

(a) The breaker shall accept current limiters of only one rating.

(b) The current limiters shall hold 300 percent of full-load motor current for a minimum of 30 minutes.

(c) The current limiters, where installed in the breaker, shall not open at locked rotor current.

(d) A spare set of current limiters of correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

7-4.4 Locked Rotor Overcurrent Protection.

The only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor shall be located within the fire pump controller and shall possess the following characteristics.

(a) For a squirrel-cage or wound-rotor induction motor, the device shall be as follows:

(1) Of the time-delay type having a tripping time between 8 seconds and 20 seconds at locked rotor current

(2) Calibrated and set at a minimum of 300 percent of motor full-load current

(b) For a direct-current motor, the device shall be as follows:

(1) Of the instantaneous type

(2) Calibrated and set at a minimum of 400 percent of motor full-load current

(c) * There shall be visual means or markings clearly indicated on the device that proper settings have been made.

(d) It shall be possible to reset the device for operation immediately after tripping with the tripping characteristics thereafter remaining unchanged.

(e) Tripping shall be accomplished by opening the circuit breaker, which shall be of the external manual reset type.

Exception: Where the motor branch circuit is transferred to an alternate source supplied by an on-site generator and is protected by an overcurrent device at the generator (see 6-6.5), *the locked rotor overcurrent protection within the fire pump controller shall be permitted to be bypassed when that motor branch circuit is so connected.*

7-4.5 Motor Contactor.

7-4.5.1

The motor contactor shall be horsepower rated and shall be of the magnetic type with a contact in each ungrounded conductor.

7-4.5.2

For electrical operation of reduced-voltage controllers, timed automatic acceleration of the motor shall be provided. The period of motor acceleration shall not exceed 10 seconds.

7-4.5.3

Starting resistors shall be designed to permit one 5-second starting operation every 80 seconds for a period of not less than 1 hour.

7-4.5.4

Starting reactors and autotransformers shall be designed to permit one 15-second starting operation every 240 seconds for a period of not less than 1 hour.

Exception: Designs in accordance with the requirements of NEMA Industrial Control and Systems Standards, ICS 2.2, Maintenance of Motor Controllers After a Fault Condition, for medium-duty service shall be acceptable for controllers over 200 horsepower.

7-4.5.5

For controllers of 600 V or less, the operating coil for the main contactor shall be supplied directly from the main power voltage and not through a transformer.

7-4.5.6

No undervoltage, phase-loss, frequency-sensitive, or other sensor(s) shall be installed that automatically or manually prohibit actuation of the motor contactor.

Exception: Sensors shall be permitted to prevent a three-phase motor from starting under single-phase condition. Such sensors shall not cause disconnection of the motor if running at time of single-phase occurrence. Such sensors shall be monitored to provide a local visible alarm in the event of malfunction of the sensors.*

7-4.6* Alarm and Signal Devices on Controller.

7-4.6.1 Power Available Visible Indicator.

A visible indicator shall monitor the availability of power in all phases at the line terminals of the motor contactor. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

Exception: When power is supplied from multiple power sources, monitoring of each power source for phase loss shall be permitted at any point electrically upstream of the line terminals of the contactor provided all sources are monitored.

7-4.6.2 Phase Reversal.

Phase reversal of the power source to which the line terminals of the motor contactor are connected shall be indicated by a visible indicator.

Exception: When power is supplied from multiple power sources, monitoring of each power source for phase reversal shall be permitted at any point electrically upstream of the line terminals of the contactor provided all sources are monitored.

7-4.7* Alarm and Signal Devices Remote from Controller.

Where the pump room is not constantly attended, audible or visible alarms powered by a source not exceeding 125 V shall be provided at a point of constant attendance. These alarms shall indicate the following.

(a) *Pump or Motor Running.* The alarm shall actuate whenever the controller has operated into a motor-running condition. This alarm circuit shall be energized by a separate reliable supervised power source or from the pump motor power, reduced to not more than 125 V.

(b) *Loss of Phase.* The loss of any phase at the line terminals of the motor contactor shall be monitored. All phases shall be monitored.

Exception: When power is supplied from multiple power sources, monitoring of each power source for phase loss shall be permitted at any point electrically upstream of the line terminals of the contactor provided all sources are monitored.

(c) *Phase Reversal. (See 7-4.6.2.)* This alarm circuit shall be energized by a separate reliable supervised power source or from the pump motor power, reduced to not more than 125 V.

(d) *Controller Connected to Alternate Source*. Where two sources of power are supplied to meet the requirements of 6-2.3, this alarm circuit shall indicate whenever the alternate source is the source supplying power to the controller. This alarm circuit shall be energized by a separate reliable, supervised power source, reduced to not more than 125 V.

7-4.8 Controller Alarm Contacts for Remote Indication.

Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions in 7-4.7(a) through (c) and when a controller is equipped with a transfer switch in accordance with 7-8.2.2(d).

7-5 Starting and Control.

7-5.1* Automatic and Nonautomatic.

7-5.1.1

An automatic controller shall be self-acting to start, run, and protect a motor. An automatic controller shall be pressure switch actuated or nonpressure switch actuated. An automatic controller shall be operable also as a nonautomatic controller.

7-5.1.2

A nonautomatic controller shall be actuated by manually initiated electrical means and by manually initiated mechanical means.

7-5.2 Automatic Controller.

7-5.2.1* Water Pressure Control.

There shall be provided a pressure-actuated switch having independent high- and low-calibrated adjustments in the controller circuit. There shall be no pressure snubber or restrictive orifice employed within the pressure switch. This switch shall be responsive to water pressure in the fire protection system. The pressure-sensing element of the switch shall be capable of withstanding a momentary surge pressure of 400 psi (27.6 bar) without losing its accuracy. Suitable provision shall be made for relieving pressure to the pressure-actuated switch to allow testing of the operation of the controller and the pumping unit. *[See Figures A-7-5.2.1(a) and (b).]*

Water pressure control shall be as follows.

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

(b) The pressure-sensing line connection for each pump, including jockey pumps, shall be made between that pump's discharge check valve and discharge control valve. This line shall be brass, copper, or series 300 stainless steel pipe or tube, and the fittings shall be of $^{1}/_{2}$-in. (12.7-mm) nominal size. There shall be two check valves installed in the pressure-sensing line at least 5 ft (1.5 m) apart with a $^{3}/_{32}$-in. (2.4-mm) hole drilled in the clapper to serve as dampening. *[See Figures A-7-5.2.1(a) and (b).]*

Exception No. 1: If water is clean, ground-face unions with noncorrosive diaphragms drilled with $^{3}/_{32}$-in. (2.4-mm) orifices shall be permitted in place of the check valves.

Exception No. 2: In a nonpressure-actuated controller, the pressure-actuated switch shall not be required.

(c) There shall be no shutoff valve in the pressure-sensing line.

(d) Pressure switch actuation at the low adjustment setting shall initiate pump starting sequence (if pump is not already in operation).

(e) * A listed pressure recording device shall be installed to sense and record the pressure in each fire pump controller pressure-sensing line at the input to the controller. The recorder shall be capable of operating for at least 7 days without being reset or rewound.

The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 400 psi (27.6 bar) without losing its accuracy.

7-5.2.2 Nonpressure Switch-Actuated Automatic Controller.

Nonpressure switch-actuated automatic fire pump controllers shall commence its starting sequence by the automatic opening of a remote contact(s). The pressure switch shall not be required. There shall be no means capable of stopping the fire pump motor except those on the fire pump controller.

7-5.2.3 Fire Protection Equipment Control.

Where the pump supplies special water control equipment (deluge valves, dry pipe valves, etc.) it may be desirable to start the motor before the pressure-actuated switch(es) would do so. Under such conditions the controller shall be equipped to start the motor upon operation of the fire protection equipment. Starting of the motor shall be initiated by the opening of a normally closed contact on the fire protection equipment.

7-5.2.4 Manual Electric Control at Remote Station.

Where additional control stations for causing nonautomatic continuous operation of the pumping unit, independent of the pressure-actuated switch, are provided at locations remote from the controller, such stations shall not be operable to stop the motor.

7-5.2.5 Sequence Starting of Pumps.

The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one motor from starting simultaneously with any other motor. Each pump supplying suction pressure to another pump shall be arranged to start before the pump it supplies. If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds. Failure of a leading motor to start shall not prevent subsequent pumping units from starting.

7-5.2.6 External Circuits Connected to Controllers.

External control circuits that extend outside the fire pump room shall be arranged so that failure of any external circuit (open or short circuit) shall not prevent operation of pump(s) from all other internal or external means. Breakage, disconnecting, shorting of the wires, or loss of power to these circuits can cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits. All control conductors within the fire pump room that are not fault tolerant as described shall be protected against mechanical injury.

7-5.3 Nonautomatic Controller.

7-5.3.1 Manual Electric Control at Controller.

There shall be a manually operated switch on the control panel so arranged that, when the motor is started manually, its operation cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down.

7-5.3.2* Emergency-Run Mechanical Control at Controller.

Emergency-run mechanical control shall consist of the following.

(a) The controller shall be equipped with an emergency-run handle or lever that operates to mechanically close the motor-circuit switching mechanism. This handle or lever shall provide for nonautomatic continuous running operation of the motor(s), independent of any electric control circuits, magnets, or equivalent devices and independent of the pressure-activated control switch. Means shall be incorporated for mechanically latching or holding the handle or lever for manual operation in the actuated position. The mechanical latching shall not be automatic, but at the option of the operator.

(b) The handle or lever shall be arranged to move in one direction only from the off position to the final position.

(c) The motor starter shall return automatically to the off position in case the operator releases the starter handle or lever in any position but the full running position.

7-5.4 Methods of Stopping.

Shutdown shall be accomplished by the following methods.

(a) *Manual.* Operation of a pushbutton on the outside of the controller enclosure that, in the case of automatic controllers, shall return the controller to the full automatic position.

(b) *Automatic Shutdown After Automatic Start (Optional).* If the controller is arranged for automatic shutdown after starting causes have returned to normal, a running period timer set for at least 10 minutes running time shall be permitted to commence at initial operation.

Exception: Automatic shutdown shall not be permitted where the pump constitutes the sole supply of a fire sprinkler or standpipe system or where the authority having jurisdiction has required manual shutdown.

7-6 Controllers Rated in Excess of 600 V.

7-6.1 Control Equipment.

Controllers rated in excess of 600 V shall comply with the requirements of Chapter 7, except as provided in 7-6.2 through 7-6.8.

7-6.2 Provisions for Testing.

The provisions of 7-3.4.2 shall not apply. An ammeter(s) shall be provided on the controller with a suitable means for reading the current in each phase. An indicating voltmeter(s), deriving power of not more than 125 V from a transformer(s) connected to the high-voltage supply, shall also be provided with a suitable means for reading each phase voltage.

7-6.3 Disconnecting Under Load.

7-6.3.1

Provisions shall be made to prevent the isolating switch from being opened under load.

7-6.3.2

A load-break disconnecting means shall be permitted to be used in lieu of the isolating switch if the fault closing and interrupting ratings equal or exceed the requirements of the installation.

7-6.4 Pressure-Actuated Switch Location.

Special precautions shall be taken in locating the pressure-actuated switch called for in 7-5.2.1 to prevent any water leakage from coming in contact with high-voltage components.

7-6.5 Low-Voltage Control Circuit.

The low-voltage control circuit shall be supplied from the high-voltage source through a step-down transformer(s) protected by high-voltage fuses in each primary line. Its power supply shall be interrupted when the isolating switch is in the open position. The secondary of the transformer and control circuitry shall otherwise comply with 7-3.5. One secondary line shall be grounded unless all control and operator devices are rated for use at the high (primary) voltage.

7-6.6 Alarm and Signal Devices on Controller.

Specifications for controllers rated in excess of 600 V differ from those in 7-4.6. A visible indicator shall be provided to indicate that power is available. The current supply for the visible indicator shall come from the secondary of the control circuit transformer through resistors, if found necessary, or from a small-capacity step-down transformer, which shall reduce the control transformer secondary voltage to that required for the visible indicator. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

7-6.7 Protection of Personnel from High Voltage.

Necessary provisions shall be made, including such interlocks as can be needed, to protect personnel from accidental contact with high voltage.

7-6.8 Disconnecting Means.

A contactor in combination with current-limiting motor circuit fuses shall be permitted to be used in lieu of the circuit breaker (disconnecting means) required in 7-4.3.1 if all of the following requirements are met.

(a) Current-limiting motor circuit fuses shall be mounted in the enclosure between the isolating switch and the contactor. They shall interrupt the short-circuit current available at the controller input terminals.

(b) These fuses shall have an adequate interrupting rating to provide the suitability rating *(see 7-1.1.2)* of the controller.

(c) The current-limiting fuses shall be sized to hold 600 percent of the full-load current rating of the motor for at least 100 seconds.

(d) A spare set of fuses of the correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

7-6.9 Locked Rotor Overcurrent Protection.

Tripping of the locked rotor overcurrent device required by 7-4.4 shall be permitted to be accomplished by opening the motor contactor coil circuit(s) to drop out the contactor. Means shall be provided to restore the controller to normal operation by an external manually reset device.

7-6.10 Emergency-Run Mechanical Control at Controller.

The controller shall comply with 7-5.3.2(a) and (b) except the mechanical latching can be automatic. When the contactor is latched-in, the locked rotor overcurrent protection of 7-4.4 shall not be required.

7-7* Limited Service Controllers.

Limited service controllers consisting of automatic controllers for across-the-line starting of squirrel-cage motors of 30 horsepower or less, 600 V or less, shall be permitted to be installed where such use is acceptable to the authority having jurisdiction. The provisions of Sections 7-1 through 7-5 shall apply.

Exception No. 1: In lieu of 7-4.3.3(2) and 7-4.4, the locked rotor overcurrent protection shall be permitted to be achieved by using an inverse time nonadjustable circuit breaker having a standard rating between 150 percent and 250 percent of the motor full-load current.

Exception No. 2: Each controller shall be marked "Limited Service Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete electrical rating. (See 7-4.2.1.)

Exception No. 3: The controller shall have a short-circuit current rating not less than 10,000 A.

Exception No. 4: The manually operated isolating switch specified in 7-4.2 shall not be required.

7-8* Power Transfer for Alternate Power Supply.

7-8.1 General.

7-8.1.1

Where required by the authority having jurisdiction or to meet the requirements of 6-2.3 where an on-site electrical power transfer device is used for power source selection, such switch shall comply with the provisions of Section 7-8 as well as Sections 7-1, 7-2, 7-3, and 7-4.1.

7-8.1.2

Manual transfer switches shall not be used to transfer power between the normal supply and the alternate supply to the fire pump controller.

7-8.1.3

No remote device(s) shall be installed that will prevent automatic operation of the transfer switch.

7-8.2* Fire Pump Controller and Transfer Switch Arrangements.

7-8.2.1 Arrangement I (Listed Combination Fire Pump Controller and Power Transfer Switch).

7-8.2.1.1

Where the power transfer switch consists of a self-contained power switching assembly, such assembly shall be housed in a barriered compartment of the fire pump controller or in a separate enclosure attached to the controller and marked "Fire Pump Power Transfer Switch."

7-8.2.1.2

An isolating switch, complying with 7-4.2, located within the power transfer switch enclosure or compartment shall be provided ahead of the alternate input terminals of the transfer switch. The requirements of the isolating switch shall be as follows.

(1) The isolating switch shall be supervised to indicate when it is open.

(2) Supervision shall operate an audible and visible signal on the fire pump controller/automatic transfer switch combination and at a remote point where required.

(3) The isolating switch shall be suitable for the available short-circuit current of the alternate source.

7-8.2.1.3

Where the alternate source is provided by a second utility power source, the transfer switch emergency side shall be provided with an isolation switch complying with 7-4.2 and a circuit breaker complying with 7-4.3 and 7-4.4.

7-8.2.2 Arrangement II (Individually Listed Fire Pump Controller and Power Transfer Switch).

The following shall be provided.

(a) A fire pump controller power transfer switch complying with Sections 6-6 and 7-8 and a fire pump controller.

(b) An isolating switch, or service disconnect where required, ahead of the normal input terminals of the transfer switch.

(c) The transfer switch overcurrent protection shall be selected or set to indefinitely carry the locked rotor current of the fire pump motor where the alternate source is supplied by a second utility.

(d) An isolating switch ahead of the alternate source input terminals of the transfer switch that meets the following requirements.

(1) The isolating switch shall be lockable in the on position.

(2) A placard shall be externally installed on the isolating switch stating “Fire Pump Isolating Switch.” The letters shall be at least 1 in. (25.4 mm) in height.

(3) A placard shall be placed adjacent to the fire pump controller stating the location of this switch and the location of the key (if the isolating switch is locked).

(4) The isolating switch shall be supervised to indicate when it is not closed by one of the following methods:

a. Central station, proprietary, or remote station signal service

b. Local signaling service that will cause the sounding of an audible signal at a constantly attended point

c. Locking the isolating switch closed

d. Sealing of isolating switches and approved weekly recorded inspections where isolating switches are located within fenced enclosures or in buildings under the control of the owner

(5) This supervision shall operate an audible and visible signal on the transfer switch and at a remote point where required.

7-8.2.3

Each fire pump shall have its own dedicated transfer switch(es) where a transfer switch(es) is required.

7-8.2.4

The fire pump controller and transfer switch *(see 7-8.2.1 and 7-8.2.2)* shall each have a cautionary marking to indicate that the isolation switch for both the controller and transfer switch is opened before servicing the controller, transfer switch, or motor.

7-8.3 Power Transfer Switch Requirements.

7-8.3.1

The power transfer switch shall be specifically listed for fire pump service.

7-8.3.2

The power transfer switch shall be suitable for the available short-circuit currents at the transfer switch normal and alternate input terminals.

7-8.3.3

The power transfer switch shall be electrically operated and mechanically held.

7-8.3.4

The power transfer switch shall have a horsepower rating at least equal to the motor horsepower or, where rated in amperes, shall have an ampere rating not less than 115 percent of the motor full-load current and also suitable for switching the motor locked rotor current.

7-8.3.5

A means for safe manual (nonelectrical) operation of the power transfer switch shall be provided. This manual means shall not be required to be externally operable.

7-8.3.6

The power transfer switch shall be provided with undervoltage-sensing devices to monitor all ungrounded lines of the normal power source. Where the voltage on any phase at the load terminals of the circuit breaker within the fire pump controller falls below 85 percent of motor-rated voltage, the power transfer switch shall automatically initiate transfer to the alternate source. Where the voltage on all phases of the normal source returns to within acceptable limits, the fire pump controller shall be permitted to be retransferred to the normal source. Phase reversal of the normal source power *(see 7-4.6.2)* shall cause a simulated normal source power failure upon sensing phase reversal.

Exception: Where the power transfer switch is electrically upstream of the fire pump controller circuit breaker, voltage shall be permitted to be sensed at the input to the power transfer switch in lieu of at the load terminals of the fire pump controller circuit breaker.

7-8.3.7

Voltage- and frequency-sensing devices shall be provided to monitor at least one ungrounded conductor of the alternate power source. Transfer to the alternate source shall be inhibited until there is adequate voltage and frequency to serve the fire pump load.

Exception: Where the alternate source is provided by a second utility power source, undervoltage-sensing devices shall monitor all ungrounded conductors in lieu of a frequency-sensing device.

7-8.3.8

Two visible indicators shall be provided to externally indicate the power source to which the fire pump controller is connected.

7-8.3.9

Means shall be provided to delay retransfer from the alternate power source to the normal source until the normal source is stabilized. This time delay shall be automatically bypassed if the alternate source fails.

7-8.3.10

Means shall be provided to prevent higher-thannormal inrush currents when transferring the fire pump motor from one source to the other.

7-8.3.11

The power transfer switch shall not have integral short-circuit or overcurrent protection.

7-8.3.12

The following shall be provided:

(1) A device to delay starting of the alternate source generator to prevent nuisance starting in the event of momentary dips and interruptions of the normal source

(2) A circuit loop to the alternate source generator whereby either the opening or closing of the circuit will start the alternate source generator (when commanded by the power transfer switch) *(see 7-8.3.6)*

(3) A means to prevent sending of the signal for starting of the alternate source generator when commanded by the power transfer switch, if the isolation switch on the alternate source side of the transfer switch is open

7-8.3.13

A momentary test switch, externally operable, shall be provided on the enclosure that will simulate a normal power source failure.

7-8.3.14

Auxiliary open or closed contacts mechanically operated by the fire pump power transfer switch mechanism shall be provided for remote indication that the fire pump controller has been transferred to the alternate source.

7-9 Controllers for Foam Concentrate Pump Motors.

7-9.1 Control Equipment.

Controllers for foam concentrate pump motors shall comply with the requirements of Sections 7-1 through 7-5, or 7-7 (and 7-8, where required) except as provided in 7-9.2 through 7-9.5.

7-9.2 Automatic Starting.

In lieu of the pressure-actuated switch described in 7-5.2.1, automatic starting shall be capable of being accomplished by the automatic activation of either a remote normally open contact or a remote normally closed contact.

7-9.3 Methods of Stopping.

The running period timer described in 7-5.4(b), if required, shall be set to less than 10 minutes but not less than 1 minute in controllers used in foam service. Manual shutdown shall be provided. Automatic shutdown shall not be permitted.

7-9.4 Lockout.

Where required, the controller shall contain a lockout feature when used in a duty-standby application. Where supplied, this lockout shall be indicated by a visible indicator and provisions for annunciating the condition at a remote location.

7-9.5 Marking.

The controller shall be marked “Foam Pump Controller.”

Chapter 8 Diesel Engine Drive

8-1 General.

8-1.1 Selection.

Selection of diesel engine-driven fire pump equipment for each situation shall be based on careful consideration of the following factors:

(1) Most reliable type of control

(2) Fuel supply

(3) Installation

(4) The starting and running operation of the diesel engine

8-1.2 Experience Record.

The compression ignition diesel engine has proved to be the most dependable of the internal combustion engines for driving fire pumps. Except for installations made prior to adoption of the 1974 edition, spark-ignited internal combustion engines shall not be used. This restriction shall not be interpreted to exclude gas turbine engines as future pump drivers.

8-2 Engines.

8-2.1 Listing.

8-2.1.1

Engines shall be listed for fire pump service.

8-2.1.2

Engines shall be specifically listed for fire pump service by a testing laboratory.

8-2.2 Engine Ratings.

8-2.2.1*

Engines shall be rated at standard Society of Automotive Engineers (SAE) conditions of 29.61 in. Hg (752.1 mm Hg) barometer and 77°F (25°C) inlet air temperature [approximately 300 ft (91.4 m) above sea level] by the testing laboratory.

8-2.2.2

Engines shall be acceptable for horsepower ratings listed by the testing laboratory for standard SAE conditions.

8-2.2.3

In special cases, engines outside the power range and type of listed engines shall have a horsepower capability, where equipped for fire pump driver service, not less than 10 percent greater than the maximum brake horsepower required by the pump under any conditions of pump load. The engine shall meet all the other requirements of listed engines.

8-2.2.4*

A deduction of 3 percent from engine horsepower rating at standard SAE conditions shall be made for diesel engines for each 1000 ft (305 m) of altitude above 300 ft (91.4 m).

8-2.2.5*

A deduction of 1 percent from engine horsepower rating as corrected to standard SAE conditions shall be made for diesel engines for every 10°F (5.6°C) above 77°F (25°C) ambient temperature.

8-2.2.6

Where right-angle gear drives *(see 8-2.3.2)* are used between the vertical turbine pump and its driver, the horsepower requirement of the pump shall be increased to allow for power loss in the gear drive.

8-2.2.7

After complying with the requirements of 8-2.2.1 through 8-2.2.6, engines shall have a 4-hour minimum horsepower rating equal to or greater than the brake horsepower required to drive the pump at its rated speed under any conditions of pump load.

8-2.3 Engine Connection to Pump.

8-2.3.1 Horizontal Shaft Pumps.

Engines shall be connected to horizontal shaft pumps by means of a flexible coupling or flexible connecting shaft listed for this service. The flexible coupling shall be directly attached to the engine flywheel adapter or stub shaft. *(See Section 3-5.)*

8-2.3.2 Vertical Shaft Turbine-Type Pumps.

Engines shall be connected to vertical shaft pumps by means of a right-angle gear drive with a listed flexible connecting shaft that will prevent undue strain on either the engine or gear drive. *(See Section 4-5.)*

Exception: Diesel engines and steam turbines designed and listed for vertical installation with vertical shaft turbine-type pumps shall be permitted to employ solid shafts and do not require a right-angle drive but do require a nonreverse ratchet.

8-2.4 Instrumentation and Control.

8-2.4.1 Governor.

Engines shall be provided with a governor capable of regulating engine speed within a range of 10 percent between shutoff and maximum load condition of the pump. The governor shall be field adjustable, and set and secured to maintain rated pump speed at maximum pump load.

8-2.4.2 Overspeed Shutdown Device.

Engines shall be provided with an overspeed shutdown device. It shall be arranged to shut down the engine at a speed approximately 20 percent above rated engine speed and to be manually reset. A means shall be provided to indicate an overspeed trouble signal to the automatic engine controller such that the controller cannot be reset until the overspeed shutdown device is manually reset to normal operating position.

8-2.4.3 Tachometer.

A tachometer shall be provided to indicate revolutions per minute of the engine. The tachometer shall be the totalizing type, or an hour meter shall be provided to record total time of engine operation.

8-2.4.4 Oil Pressure Gauge.

Engines shall be provided with an oil pressure gauge to indicate lubricating oil pressure.

8-2.4.5 Temperature Gauge.

Engines shall be provided with a temperature gauge to indicate engine coolant temperature at all times.

8-2.4.6 Instrument Panel.

All engine instruments shall be placed on a suitable panel secured to the engine at a suitable point.

8-2.4.7* Automatic Controller Wiring in Factory.

All connecting wires for automatic controllers shall be harnessed or flexibly enclosed, mounted on the engine, and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller.

8-2.4.8* Automatic Control Wiring in the Field.

Interconnections between the automatic controller and engine junction box shall be made using stranded wire sized on a continuous-duty basis.

8-2.4.9* Main Battery Contactors.

The main battery contactors supplying current to the starting motor shall be capable of manual mechanical operation to energize the starting motor in the event of control circuit failure.

8-2.4.10 Signal for Engine Running and Crank Termination.

Engines shall be provided with a speed-sensitive switch to signal engine running and crank termination. Power for this signal shall be taken from a source other than the engine generator or alternator.

8-2.4.11 Wiring Elements.

All wiring on the engine including starting circuitry shall be sized on a continuous-duty basis.

Exception: Battery cables shall be provided according to the engine manufacturer's recommendations.

8-2.5 Starting Methods.

8-2.5.1 Starting Devices.

Engines shall be equipped with a reliable starting device.

8-2.5.2 Electric Starting.

Where electric starting is used, the electric-starting device shall take current from a storage battery(ies).

8-2.5.2.1 Number and Capacity of Batteries.

Each engine shall be provided with two storage battery units. At 40°F (4.5°C), each battery unit shall have twice the capacity sufficient to maintain the cranking speed recommended by the engine manufacturer through a 3-minute attempt-to-start cycle, which is 15 seconds of cranking and 15 seconds of rest, in six consecutive cycles.

8-2.5.2.2 Battery.

Lead-acid batteries shall be furnished in a dry charge condition with electrolyte liquid in a separate container. Electrolyte shall be added at the time the engine is put in service and the battery is given a conditioning charge. Nickel-cadmium batteries shall be furnished according to the manufacturer's requirements.

Exception: Other kinds of batteries shall be permitted to be installed in accordance with *the manufacturer's requirements.*

8-2.5.2.3* Battery Recharging.

Two means for recharging storage batteries shall be provided. One shall be the generator or alternator furnished with the engine. The other shall be an automatically controlled charger taking power from an alternating current power source.

Exception: If an alternating current power source is not available or is not reliable, another charging method, in addition to the generator or alternator furnished with the engine, shall be provided.

8-2.5.2.4 Battery Chargers.

The requirements for battery chargers shall be as follows.

(a) Chargers shall be specifically listed for fire pump service.

(b) The rectifier shall be a semiconductor type.

(c) The charger for a lead-acid battery shall be a type that automatically reduces the charging rate to less than 500 mA when the battery reaches a full charge condition.

(d) The battery charger at its rated voltage shall be capable of delivering energy into a fully discharged battery in such a manner that it will not damage the battery. It shall restore to the battery 100 percent of the battery's reserve capacity or ampere-hour rating within 24 hours.

(e) The charger shall be marked with the reserve capacity or ampere-hour rating of the largest capacity battery that it can recharge in compliance with 8-2.5.2.4(d).

(f) An ammeter with an accuracy of 5 percent of the normal charging rate shall be furnished to indicate the operation of the charger.

(g) The charger shall be designed such that it will not be damaged or blow fuses during the cranking cycle of the engine when operated by an automatic or manual controller.

(h) The charger shall automatically charge at the maximum rate whenever required by the state of charge of the battery.

(i) The battery charger shall be arranged to indicate loss of current output on the load side of the direct current (dc) overcurrent protective device where not connected through a control panel. *[See 9-4.1.3(f).]*

8-2.5.2.5* Battery Location.

Storage batteries shall be rack-supported above the floor, secured against displacement, and located where they will not be subject to excessive temperature, vibration, mechanical injury, or flooding with water. They shall be readily accessible for servicing. Battery cables shall be sized in accordance with the engine manufacturer's recommendations considering the cable length required for the specific battery location.

8-2.5.2.6 Current-Carrying Part Location.

Current-carrying parts shall not be less than 12 in. (305 mm) above the floor level.

8-2.5.3 Hydraulic Starting.

8-2.5.3.1

Where hydraulic starting is used, the accumulators and other accessories shall be cabinetized or so guarded that they are not subject to mechanical injury. The cabinet shall be installed as close to the engine as practical so as to prevent serious pressure drop between engine and cabinet. The diesel engine as installed shall be without starting aid except that a thermostatically controlled electric water jacket heater shall be employed. The diesel as installed shall be capable of carrying its full rated load within 20 seconds after cranking is initiated with the intake air, room ambient temperature, and all starting equipment at 32°F (0°C).

8-2.5.3.2

Hydraulic starting means shall comply with the following conditions.

(a) The hydraulic cranking device shall be a self-contained system that will provide the required cranking forces and engine starting revolutions per minute (rpm) as recommended by the engine manufacturer.

(b) Electrically operated means shall automatically provide and maintain the stored hydraulic pressure within the predetermined pressure limits.

(c) The means of automatically maintaining the hydraulic system within the predetermined pressure limits shall be energized from the main bus and final emergency bus if one is provided.

(d) Means shall be provided to manually recharge the hydraulic system.

(e) The capacity of the hydraulic cranking system shall provide not less than six cranking cycles. Each cranking cycle — the first three to be automatic from signaling source — shall provide the necessary number of revolutions at the required rpm to permit the diesel engine to meet the requirements of carrying its full rated load within 20 seconds after cranking is initiated with intake air, room ambient temperature, and hydraulic cranking system at 32°F (0°C).

(f) The capacity of the hydraulic cranking system sufficient for three starts under conditions described in 8-2.5.3.2(e) shall be held in reserve and arranged so that the operation of a single control by one person will permit the reserve capacity to be employed.

(g) All controls for engine shutdown in event of low engine lube, overspeed, and high water jacket temperature shall be 12- or 24-V dc source to accommodate controls supplied on engine. In the event of such failure, the hydraulic cranking system shall provide an interlock to prevent the engine from recranking. The interlock shall be manually reset for automatic starting when engine failure is corrected.

8-2.5.4 Air Starting.

8-2.5.4.1 Existing Requirements.

In addition to the requirements in Section 8-1 through 8-2.4.6, 8-2.5.1, 8-2.6 through 8-6.2, 8-6.4, and 8-6.5, the following requirements shall apply.

8-2.5.4.2 Automatic Controller Connections in Factory.

All conductors for automatic controllers shall be harnessed or flexibly enclosed, mounted on the engine, and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller. These requirements shall ensure ready connection in the field between the two sets of terminals.

8-2.5.4.3 Signal for Engine Running and Crank Termination.

Engines shall be provided with a speed-sensitive switch to signal running and crank termination. Power for this signal shall be taken from a source other than the engine compressor.

8-2.5.4.4* Air Starting Supply.

8-2.5.4.4.1

The air supply container shall be sized for 180 seconds of continuous cranking without recharging. There shall be a separate, suitably powered automatic air compressor or means of obtaining air from some other system, independent of the compressor driven by the fire pump engine. Suitable supervisory service shall be maintained to indicate high and low air pressure conditions.

8-2.5.4.4.2

A bypass conductor with a manual valve or switch shall be installed for direct application of air from the air container to the engine starter in the event of control circuit failure.

8-2.6 Engine Cooling.

8-2.6.1

The engine cooling system shall be included as part of the engine assembly and shall be one of the following closed-circuit types:

(1) A heat exchanger type that includes a circulating pump driven by the engine, a heat exchanger, and an engine jacket temperature regulating device

(2) A radiator type that includes a circulating pump driven by the engine, a radiator, an engine jacket temperature regulating device, and an engine-driven fan for providing positive movement of air through the radiator

8-2.6.2 Coolant and Fill Openings.

An opening shall be provided in the circuit for filling the system, checking coolant level, and adding make-up coolant when required. The coolant shall comply with the recommendation of the engine manufacturer.

8-2.6.3* Heat Exchanger Water Supply.

8-2.6.3.1 Supply.

The cooling water supply for a heat exchanger-type system shall be from the discharge of the pump taken off prior to the pump discharge check valve. Threaded rigid piping shall be used for this connection. The pipe connection in the direction of flow shall include an indicating manual shutoff valve, an approved flushing-type strainer in addition to the one that can be a part of the pressure regulator, a pressure regulator, an automatic valve listed for fire protection service, and a second indicating manual shutoff valve. A pressure gauge shall be installed in the cooling water supply system on the engine side of the last manual valve.

Exception: The automatic valve is not required on a vertical shaft turbine-type pump or any other pump when there is no pressure in the discharge when the pump is idle.

8-2.6.3.2 Pressure Regulator.

The pressure regulator shall be of such size and type that it is capable of and adjusted for passing approximately 120 percent of the cooling water required when the engine is operating at maximum brake horsepower and when the regulator is supplied with water at the pressure of the pump when it is pumping at 150 percent of its rated capacity. The cooling water flow required shall be set based on the maximum ambient cooling water.

8-2.6.3.3 Automatic Valve.

An automatic valve shall permit flow of cooling water to the engine when it is running.

8-2.6.4* Heat Exchanger Water Supply Bypass.

A bypass line with manual valves, a flush-type strainer, and a pressure regulator shall be installed around the manual shutoff valve, strainer, pressure regulator, and automatic valve.

8-2.6.5 Heat Exchanger Waste Outlet.

8-2.6.5.1

An outlet shall be provided for the wastewater line from the heat exchanger, and the discharge line shall not be less than one size larger than the inlet line. The outlet line shall be as short as practical, shall provide discharge into a visible open waste cone, and shall have no valves in it.

Exception: It shall be permitted to discharge to a suction reservoir provided a visual flow indicator and temperature indicator are installed.

8-2.6.5.2

When the waste outlet piping is longer than 15 ft (4.8 m) and/or its outlet discharges more than 4 ft (1.2 m) higher than the heat exchanger, the pipe size shall be increased by at least one size.

8-2.6.6 Radiators.

8-2.6.6.1

The heat from the primary circuit of a radiator shall be dissipated by a fan included with, and driven by, the engine. The radiator shall be designed to limit maximum engine operating temperature with an inlet air temperature of 120°F (49°C) at the combustion air cleaner inlet. The radiator shall include the plumbing to the engine and a flange on the air discharge side for the connection of a flexible duct from the discharge side to the discharge air ventilator.

8-2.6.6.2

The fan shall push the air through the radiator to be exhausted from the room via the air discharge ventilator. To ensure adequate air flow through the room and radiator, the radiator cooling package shall be capable of a 0.5 in. water column (13 mm water column) restriction created by the combination of the air supply and the discharge ventilators. This external restriction shall be in addition to the radiator, fan guard, and other engine component obstructions. The fan shall be guarded for personnel protection.

8-3* Pump and Engine Protection.

8-3.1 Pump Room Drainage.

The floor or surface around the pump and engine shall be pitched for adequate drainage of escaping water away from critical equipment, such as pump, engine, controller, fuel tank, and so forth.

8-3.2* Ventilation.

Ventilation shall be provided for the following functions:

(1) Control the maximum temperature to 120°F (49°C) at the combustion air cleaner inlet with engine running at rated load

(2) Supply air for engine combustion

(3) Remove any hazardous vapors

(4) Supply and exhaust air as necessary for radiator cooling of the engine when required

The ventilation system components shall be coordinated with the engine operation.

8-3.2.1* Air Supply Ventilator.

The air supply ventilator shall be considered to include anything in the air supply path to the room. The total air supply path to the pump room shall not restrict the flow of the air more than 0.2 in. water column (5.1 mm water column).

8-3.2.2* Air Discharge Ventilator.

The air discharge ventilator shall be considered to include anything in the air discharge path from the room. The air discharge ventilator shall allow sufficient air to exit the pump room to satisfy 8-3.2.

For radiator-cooled engines, the radiator discharge shall be ducted outdoors in a manner that will prevent recirculation. The duct shall be attached to the radiator via a flexible section. The air discharge path, for radiator-cooled engines, shall not restrict the flow of air more than 0.3 in. water column (7.6 mm water column).

Exception: A recirculation duct is acceptable for cold weather operation providing that the following requirements are met.

(a) The recirculation air flow is regulated by a thermostatically controlled damper.

(b) The control damper fully closes in a failure mode.

(c) The recirculated air is ducted to prevent direct recirculation to the radiator.

(d) The recirculation duct will not cause the temperature at the combustion air cleaner inlet to rise above 120°F (49°C).

8-4 Fuel Supply and Arrangement.

8-4.1 Plan Review.

Before any fuel system is installed, plans shall be prepared and submitted to the authority having jurisdiction for agreement on suitability of the system for conditions prevailing.

8-4.2 Guards.

A guard or protecting pipe shall be provided for all exposed fuel lines.

8-4.3* Fuel Tank Capacity.

Fuel supply tank(s) shall have a capacity at least equal to 1 gal per horsepower (5.07 L/kW), plus 5 percent volume for expansion and 5 percent volume for sump. Larger-capacity tanks could be required and shall be determined by prevailing conditions, such as refill cycle and fuel heating due to recirculation, and shall be subject to special conditions in each case. The fuel supply tank and fuel shall be reserved exclusively for the fire pump diesel engine.

8-4.4 Multiple Pumps.

There shall be a separate fuel line and separate fuel supply tank for each engine.

8-4.5* Fuel Supply Location.

Diesel fuel supply tanks shall be located above ground in accordance with municipal or other ordinances and in accordance with requirements of the authority having jurisdiction and shall not be buried. The engine fuel supply (suction) connection shall be located on the tank so that 5 percent of the tank volume provides a sump volume not usable by the engine. The fuel supply shall be located on a side of the tank at the level of the 5 percent sump volume. The inlet to the fuel supply line shall be located so that its opening is no lower than the level of the engine fuel transfer pump. The engine manufacturer's fuel pump static head pressure limits shall not be exceeded when the level of fuel in the tank is at a maximum.

The fuel return line shall be installed according to the engine manufacturer's recommendation. In zones where freezing temperatures [32°F (0°C)] could be encountered, the fuel tanks shall be located in the pump room. Means other than sight tubes shall be provided for determining the amount of fuel in each storage tank. Each tank shall have suitable fill, drain, and vent connections.

8-4.6* Fuel Piping.

Flame-resistant flexible hoses listed for this service shall be provided at the engine for connection to fuel system piping. There shall be no shutoff valve in the fuel return line to the tank.

8-4.7* Fuel Type.

The type and grade of diesel fuel shall be as specified by the engine manufacturer. Residual fuels, domestic heating furnace oils, and drained lubrication oils shall not be used.

8-4.8 Fuel Solenoid Valve.

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

8-5 Engine Exhaust.

8-5.1 Independent Exhaust.

Each pump engine shall have an independent exhaust system.

8-5.2 Exhaust Discharge Location.

Exhaust from the engine shall be piped to a safe point outside the pump room and arranged to exclude water. Exhaust gases shall not be discharged where they will affect persons or endanger buildings.

8-5.3* Exhaust Piping.

A seamless or welded corrugated (not interlocked) flexible connection shall be made between the engine exhaust outlet and exhaust pipe. The exhaust pipe shall not be any smaller than the engine exhaust outlet and shall be as short as possible. The exhaust pipe shall be covered with high-temperature insulation or otherwise guarded to protect personnel from injury. The exhaust pipe and muffler, if used, shall be suitable for the use intended, and the exhaust back pressure shall not exceed the engine manufacturer's recommendations.

Exhaust pipes shall be installed with clearances of at least 9 in. (229 mm) to combustible materials.

Exception No. 1: Exhaust pipes passing directly through combustible roofs shall be guarded at the point of passage by ventilated metal thimbles that extend not less than 9 in. (229 mm) above and 9 in. (229 mm) below roof construction and are at least 6 in. (152 mm) *larger in diameter than the exhaust pipe.*

Exception No. 2: Exhaust pipes passing directly through combustible walls or partitions shall be guarded at the point of passage by one of the following methods:

(a) Metal ventilated thimbles not less than 12 in. (305 mm) larger in diameter than the exhaust pipe

(b) Metal or burned clay thimbles built in brickwork or other approved materials providing not less than 8 in. (203 mm) of insulation between the thimble and construction material

8-5.3.1

Exhaust systems shall terminate outside the structure at a point where hot gases, sparks, or products of combustion will be discharged harmlessly. (**37:**7-2.3.1)

8-5.3.2

Exhaust system terminations shall not be directed toward combustible material or structures or into atmospheres containing flammable gases, flammable vapors, or combustible dusts.

*Exception: Exhaust systems equipped with spark-arresting mufflers shall be permitted to terminate in Division 2 locations as defined in Article 500 of NFPA 70, National Electrical Code. (**37:**7-2.3.2)*

8-5.4 Exhaust Manifold.

Exhaust manifolds shall incorporate provisions to avoid hazard to the operator or to flammable material adjacent to the engine.

8-6* Driver System Operation.

8-6.1 Weekly Run.

Engines shall be started no less than once a week and run for no less than 30 minutes to attain normal running temperature. They shall run smoothly at rated speed.

8-6.2* System Performance.

Engines shall be kept clean, dry, and well lubricated to ensure adequate performance.

8-6.3 Battery Maintenance.

8-6.3.1

Storage batteries shall be kept charged at all times. They shall be tested frequently to determine the condition of the battery cells and the amount of charge in the battery.

8-6.3.2

Only distilled water shall be used in battery cells. The plates shall be kept submerged at all times.

8-6.3.3

The automatic feature of a battery charger shall not be a substitute for proper maintenance of battery and charger. Periodic inspection of both shall be made. This inspection shall determine that the charger is operating correctly, the water level in the battery is correct, and the battery is holding its proper charge.

8-6.4 Fuel Supply Maintenance.

The fuel storage tanks shall be kept as full as possible at all times, but never less than 50 percent of tank capacity. The tanks shall always be filled by means that will ensure removal of all water and foreign material.

8-6.5* Temperature Maintenance.

Temperature of the pump room, pump house, or area where engines are installed shall never be less than the minimum recommended by the engine manufacturer. An engine jacket water heater shall be provided to maintain 120°F (49°C). The engine manufacturer's recommendations for oil heaters shall be followed.

8-6.6 Emergency Starting and Stopping.

The sequence for emergency manual operation, arranged in a step-by-step manner, shall be posted on the fire pump engine. It shall be the engine manufacturer's responsibility to list any specific instructions pertaining to the operation of this equipment during the emergency operation.

Chapter 9 Engine Drive Controllers

9-1 Application.

This chapter provides requirements for minimum performance of automatic/nonautomatic diesel engine controllers for diesel engine-driven fire pumps. Accessory devices, such as alarm monitoring and signaling means, are included when necessary to ensure minimum performance of the aforementioned equipment.

9-1.1 General.

9-1.1.1

All controllers shall be specifically listed for diesel engine-driven fire pump service.

9-1.1.2

All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

9-1.1.3

All controllers shall be marked “Diesel Engine Fire Pump Controller” and shall show plainly the name of the manufacturer, the identifying designation, and the complete electrical rating. Where multiple pumps serving different areas or portions of the facility are provided, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

9-1.1.4

It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a controller manufacturer’s representative, when needed, for services and adjustment of the equipment during the installation, testing, and warranty periods.

9-2 Location.

9-2.1*

Controllers shall be located as close as is practical to the engines they control and shall be within sight of the engines.

9-2.2

Controllers shall be so located or so protected that they will not be injured by water escaping from pumps or pump connections. Current-carrying parts of controllers shall not be less than 12 in. (305 mm) above the floor level.

9-2.3

Working clearances around controllers shall comply with NFPA 70, *National Electrical Code*, Article 110.

9-3 Construction.

9-3.1* Equipment.

All equipment shall be suitable for use in locations subject to a moderate degree of moisture, such as a damp basement. Reliability of operation shall not be adversely affected by normal dust accumulations.

9-3.2 Mounting.

All equipment not mounted on the engine shall be mounted in a substantial manner on a single noncombustible supporting structure.

9-3.3 Enclosures.

9-3.3.1* Mounting.

The structure or panel shall be securely mounted in, as a minimum, a NEMA Type 2 dripproof enclosure(s). Where the equipment is located outside or special environments exist, suitably rated enclosures shall be used.

9-3.3.2 Grounding.

The enclosures shall be grounded in accordance with NFPA 70, *National Electrical Code*, Article 250.

9-3.4 Locked Cabinet.

All switches required to keep the controller in the automatic position shall be within locked cabinets having break glass panels.

9-3.5 Connections and Wiring.

9-3.5.1 Field Wiring.

All wiring between the controller and the diesel engine shall be stranded and sized to carry the charging or control currents as required by the controller manufacturer. Such wiring shall be protected against mechanical injury. Controller manufacturer's specifications for distance and wire size shall be followed.

9-3.5.2 Wiring Elements.

Wiring elements of the controller shall be designed on a continuous-duty basis.

9-3.5.3 Connections.

A diesel engine fire pump controller shall not be used as a junction box to supply other equipment. Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the diesel engine fire pump controller.

9-3.6 Electrical Diagrams and Instructions.

9-3.6.1

A field connection diagram shall be provided and permanently attached to the inside of the enclosure.

9-3.6.2

The field connection terminals shall be plainly marked to correspond with the field connection diagram furnished.

9-3.6.3

For external engine connections, the field connection terminals shall be commonly numbered between the controller and engine terminals.

9-3.7 Marking.

Each operating component of the controller shall be marked to plainly indicate an identification symbol appearing on the electrical schematic diagram. The markings shall be located so as to be visible after installation.

9-3.8* Instructions.

Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

9-4 Components.

9-4.1 Alarm and Signal Devices on Controller.

9-4.1.1

All visible indicator alarms shall be plainly visible.

9-4.1.2*

Visible indication shall be provided to indicate that the controller is in the automatic position. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

9-4.1.3

Separate visible indicators and a common audible alarm capable of being heard while the engine is running and operable in all positions of the main switch except off shall be provided to indicate trouble caused by the following conditions.

(a) Critically low oil pressure in the lubrication system. The controller shall provide means for testing the position of the pressure switch contacts without causing trouble alarms.

(b) High engine jacket coolant temperature.

(c) Failure of engine to start automatically.

(d) Shutdown from overspeed.

(e) Battery failure. Each controller shall be provided with a separate visible indicator for each battery.

(f) Battery charger failure. Each controller shall be provided with a separate visible indicator for battery charger failure.

Exception: The audible alarm shall not be required for battery charger failure.

(g) Low air or hydraulic pressure. Where air or hydraulic starting is provided *(see 8-2.5 and 8-2.5.4)*, each pressure tank shall provide to the controller separate visible indicators to indicate low pressure.

9-4.1.4

No audible alarm silencing switch, other than the controller main switch, shall be permitted for the alarms required in 9-4.1.3.

9-4.2 Alarm and Signal Devices Remote from Controller.

Where the pump room is not constantly attended, audible or visible alarms powered by a source other than the engine starting batteries and not exceeding 125 V shall be provided at a point of constant attendance. These alarms shall indicate the following.

(1) The engine is running (separate signal).

(2) The controller main switch has been turned to the off or manual position (separate signal).

(3) * Trouble on the controller or engine (separate or common signals). *(See 9-4.1.3.)*

9-4.3 Controller Alarm Contacts for Remote Indication.

Controllers shall be equipped with open or closed contacts to operate circuits for the conditions covered in 9-4.2.

9-4.4* Pressure Recorder.

A listed pressure recording device shall be installed to sense and record the pressure in each fire pump controller pressure-sensing line at the input to the controller. The recorder shall be capable of operating for at least 7 days without being reset or rewound.

The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 400 psi (27.6 bar) without losing its accuracy.

The pressure-recording device shall be spring wound mechanically or driven by reliable electrical means. The pressure-recording device shall not be solely dependent upon alternating current (ac) electric power as its primary power source. Upon loss of ac electric power, the electric-driven recorder shall be capable of at least 24 hours of operation.

Exception: In a nonpressure-actuated controller, the pressure recorder shall not be required.

9-4.5 Voltmeter.

A voltmeter with an accuracy of ±5 percent shall be provided for each battery bank to indicate the voltage during cranking.

9-5* Starting and Control.

9-5.1 Automatic and Nonautomatic.

9-5.1.1

An automatic controller shall be operable also as a nonautomatic controller.

9-5.1.2

The controller's primary source of power shall not be ac electric power.

9-5.2 Automatic Operation of Controller.

9-5.2.1 Water Pressure Control.

The controller circuit shall be provided with a pressure-actuated switch having independent high- and low-calibrated adjustments. There shall be no pressure snubber or restrictive orifice employed within the pressure switch. This switch shall be responsive to water pressure in the fire protection system. The pressure-sensing element of the switch shall be capable of a momentary surge pressure of 400 psi (27.6 bar) minimum without losing its accuracy. Suitable provision shall be made for relieving pressure to the pressure-actuated switch to allow testing of the operation of the controller and the pumping unit. *[See Figures A-7-5.2.1(a) and (b).]* Water pressure control shall be as follows.

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

(b) The pressure-sensing line connection for each pump, including jockey pumps, shall be made between that pump's discharge check valve and discharge control valve. This line shall be brass, copper, or series 300 stainless steel pipe or tube, and fittings of $^1/_2$-in. (12.7-mm) nominal size. There shall be two check valves installed in the pressure-sensing line at least 5 ft (1.6 m) apart with a $^3/_{32}$-in. (2.4-mm) hole drilled in the clapper to serve as a damper. *[See Figures A-7-5.2.1(a) and (b).]*

Exception No. 1: If water is clean, ground-face unions with noncorrosive diaphragms drilled with $^3/_{32}$-in. (2.4-mm) orifices shall be permitted in place of the check valves.

Exception No. 2: In a nonpressure-actuated controller, the pressure-actuated switch shall not be required.

(c) There shall be no shutoff valve in the pressure-sensing line.

(d) Pressure switch actuation at the low adjustment setting shall initiate pump starting sequence if the pump is not already in operation.

9-5.2.2 Fire Protection Equipment Control.

Where the pump supplies special water control equipment (e.g., deluge valves, dry-pipe valves, etc.), the engine shall be started before the pressure-actuated switch(es) would do so. Under such conditions, the controller shall be equipped to start the engine upon operation of the fire protection equipment.

9-5.2.3 Manual Electric Control at Remote Station.

Additional control stations for causing nonautomatic, continuous operation of the pumping unit, independent of the pressure-actuated control switch, shall be permitted to be provided at locations remote from the controller.

9-5.2.4 Sequence Starting of Pumps.

The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one engine from starting simultaneously with any other engine. Each pump supplying suction pressure to another pump shall be arranged to start before the pump it supplies. If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds. Failure of a leading engine to start shall not prevent subsequent engines from starting.

9-5.2.5 External Circuits Connected to Controllers.

With pumping units operating singly or in parallel, the control conductors entering or leaving the fire pump controller and extending outside of the fire pump room shall be so arranged as to prevent failure to start due to fault. Breakage, disconnecting, shorting of the wires, or loss of power to these circuits could cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits. All control conductors within the fire pump room that are not fault tolerant shall be protected against mechanical injury.

9-5.2.6 Sole Supply Pumps.

Shutdown shall be accomplished by manual or automatic means.

Exception: Automatic shutdown shall not be permitted where the pump constitutes the sole source of supply of a fire sprinkler or standpipe system or where the authority having jurisdiction has required manual shutdown.

9-5.2.7 Weekly Program Timer.

To ensure dependable operation of the engine and its controller, the controller equipment shall be arranged to automatically start and run the engine for at least 30 minutes once a week. Means shall be permitted within the controller to manually terminate the weekly test provided a minimum of 30 minutes has expired. A solenoid valve drain on the pressure control line shall be the initiating means.

Performance of this weekly program timer shall be recorded as a pressure drop indication on the pressure recorder. *(See 9-4.4.)*

Exception: In a nonpressure-actuated controller, the weekly test shall be permitted to be initiated by means other than a solenoid valve.

9-5.3 Nonautomatic Operation of Controller.

9-5.3.1 Manual Control at Controller.

There shall be a manually operated switch on the controller panel. This switch shall be so arranged that operation of the engine, when manually started, cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down. Failure of any of the automatic circuits shall not affect the manual operation.

9-5.3.2 Manual Testing.

The controller shall be arranged to manually start the engine by opening the solenoid valve drain when so initiated by the operator.

9-5.4 Starting Equipment Arrangement.

The requirements for starting equipment arrangement shall be as follows.

(a) Two storage battery units, each complying with the requirements of 8-2.5.2, shall be provided and so arranged that manual and automatic starting of the engine can be accomplished with either battery unit. The starting current shall be furnished by first one battery and then the other on successive operations of the starter. The changeover shall be made automatically, except for manual start.

(b) In the event that the engine does not start after completion of its attempt-to-start cycle, the controller shall stop all further cranking and operate a visible indicator and audible alarm on the controller. The attempt-to-start cycle shall be fixed and shall consist of six crank periods of an approximately 15-second duration separated by five rest periods of an approximately 15-second duration.

(c) In the event that one battery is inoperative or missing, the control shall lock-in on the remaining battery unit during the cranking sequence.

9-5.5 Methods of Stopping.

9-5.5.1 Manual Electric Shutdown.

Manual shutdown shall be accomplished by either of the following.

(a) Operation of the main switch inside the controller.

(b) Operation of a stop button on the outside of the controller enclosure. The stop button shall cause engine shutdown through the automatic circuits only if all starting causes have been returned to normal. The controller shall then return to the full automatic position.

9-5.5.2* Automatic Shutdown After Automatic Start.

The requirements for automatic shutdown after automatic start shall be as follows.

(a) If the controller is set up for automatic engine shutdown, the controller shall shut down the engine only after all starting causes have returned to normal and a 30-minute minimum run time has elapsed.

(b) When the engine emergency overspeed device operates, the controller shall remove power from the engine running devices, prevent further cranking, energize the overspeed alarm, and lock out until manually reset. Resetting of the overspeed circuit shall be required at the engine and by resetting the controller main switch to the off position.

(c) The engine shall not shut down automatically on high water temperature or low oil pressure when any starting cause exists. If no other starting cause exists during engine test, shutdown shall be permitted.

(d) The controller shall not be capable of being reset until the engine overspeed shutdown device is manually reset.

9-5.6 Emergency Control.

Automatic control circuits, the failure of which could prevent engine starting and running, shall be completely bypassed during manual start and run.

9-6 Air-Starting Engine Controllers.

9-6.1 Existing Requirements.

In addition to the requirements in Section 9-1 and 9-1.1.1, 9-1.1.4 through 9-3.4, 9-3.8, Section 9-5 through 9-5.2.1(b), 9-5.2.4, 9-5.2.7, and 9-5.5.2 through 9-5.6, the following subsections shall apply.

9-6.2 Assembly and Testing.

All controllers shall be completely assembled and tested by the manufacturer before shipment from the factory.

9-6.3 Marking.

All controllers shall be marked "Diesel Engine Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete rating. Where multiple pumps serving different areas or portions of the facility are provided, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

9-6.4 Connections.

9-6.4.1 Field Connections.

All conductors from the panel to the engine and starter support shall have adequate current-carrying capacity. Such conductors shall be protected against mechanical injury. Controller manufacturer's specifications for distance and conductor size shall be followed.

9-6.4.2 Conductor Elements.

Conductor elements of the controller shall be designed to operate on a continuous-duty basis.

9-6.5 Circuit Diagrams and Instructions.

A circuit diagram shall be provided and permanently attached to the inside of the enclosure showing exact circuitry for the controller, including identifying numbers of individual components. All circuit terminals shall be plainly and commonly marked and numbered to correspond with the circuit diagram furnished. For external engine connections, the connection strips shall be commonly numbered.

9-6.6 Marking.

Each operating component of the controller shall be marked to plainly indicate an identifying number referenced to the circuit diagram. The markings shall be located so as to be visible after installation.

9-6.7 Alarm and Signal Devices on Controller.

9-6.7.1

A visible indicator(s) shall be provided to indicate that the controller is in the automatic position. The visible indicator shall be accessible for replacement.

9-6.7.2

Separate visible indicators and a common audible alarm shall be provided to indicate trouble caused by the following conditions.

(a) Critically low oil pressure in the lubrication system. The controller shall provide means for testing the position of the pressure switch contacts without causing trouble alarms.

(b) High engine jacket coolant temperature.

(c) Failure of engine to start automatically.

(d) Shutdown from overspeed.

(e) Low air pressure. The air supply container shall be provided with a separate visible indicator to indicate low air pressure.

9-6.7.3

No audible alarm silencing switch or valve, other than the controller main switch or valve, shall be permitted for the alarms in 9-6.7.2.

9-6.7.4

Where audible alarms for the conditions listed in A-2-18 are incorporated with the engine alarms specified in 9-6.7.2, a silencing switch or valve for the A-2-18 audible alarms shall be provided at the controller. The circuit shall be arranged so that the audible alarm will be activated if the silencing switch or valve is in the silent position when the supervised conditions are normal.

9-6.8 Alarms for Remote Indication.

Controllers shall be equipped to operate circuits for remote indication of the conditions covered in 9-4.1.3 and 9-4.2(1) through (3).

9-6.9* Pressure Recorder.

A listed pressure recording device shall be installed to sense and record the pressure in each fire pump controller pressure-sensing line at the input to the controller. The recorder shall be capable of operating for at least 7 days without being reset or rewound.

The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 400 psi (27.6 bar) without losing its accuracy.

The pressure-recording device shall be spring wound mechanically or driven by reliable electrical means. The pressure-recording device shall not be solely dependent upon ac electric power. Upon loss of ac electric power, the electric-driven recorder shall be capable of at least 24 hours of operation.

Exception: In a nonpressure-actuated controller, the pressure recorder shall not be required.

9-6.10 Fire Protection Equipment Control.

Where the pump supplies special water control equipment (e.g., deluge valves, dry-pipe valves, etc.), the engine shall be started before the pressure-actuated valve or switch would do so. Under such conditions the controller shall be equipped to start the engine upon operation of the fire protection equipment.

9-6.11 Manual Control at Remote Station.

Additional control stations for causing nonautomatic, continuous operation of the pumping unit, independent of the pressure-actuated control valve or switch, could be provided at locations remote from the controller. Such stations shall not be operable to stop the unit except through the established operation of the running period timer circuit when the controller is arranged for automatic shutdown. *(See 9-5.4.2.)*

9-6.12 External Circuits Connected to Controllers.

With pumping units operating singly or in parallel, the control conductors entering or leaving the fire pump controller that extend outside the fire pump room shall be arranged so as to prevent failure to start due to fault. Breakage, disconnecting, shorting of wires, or loss of power to these circuits could cause continuous running of the fire pump, but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits. All control conductors within the fire pump room that are not fault tolerant shall be protected against mechanical injury.

9-6.13 Sole Supply Pumps.

For sprinkler or standpipe systems where an automatically controlled pumping unit constitutes the sole supply, the controller shall be arranged for manual shutdown. Manual shutdown shall also be provided where required by the authority having jurisdiction.

9-6.14 Manual Control at Controller.

There shall be a manually operated valve or switch on the controller panel. This valve or switch shall be so arranged that operation of the engine, when manually started, cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down.

9-6.15 Starting Equipment Arrangement.

The requirements for starting equipment arrangement shall be as follows.

(a) The air supply container, complying with the requirements of 8-2.5.4.4, shall be provided and so arranged that manual and automatic starting of the engine can be accomplished.

(b) In the event that the engine does not start after completion of its attempt-to-start cycle, the controller shall stop all further cranking and operate the audible and visible alarms. The attempt-to-start cycle shall be fixed and shall consist of one crank period of an approximately 90-second duration.

9-6.16 Manual Shutdown.

Manual shutdown shall be accomplished by either of the following.

(a) Operation of a stop valve or switch on the controller panel.

(b) Operation of a stop valve or switch on the outside of the controller enclosure. The stop valve shall cause engine shutdown through the automatic circuits only after starting causes have been returned to normal. This action shall return the controller to full automatic position.

Chapter 10 Steam Turbine Drive

10-1 General.

10-1.1 Acceptability.

10-1.1.1

Steam turbines of adequate power are acceptable prime movers for driving fire pumps. Reliability of the turbines shall have been proved in commercial work.

10-1.1.2

The steam turbine shall be directly connected to the fire pump.

10-1.2 Turbine Capacity.

10-1.2.1

For steam boiler pressures not exceeding 120 psi (8 bar), the turbine shall be capable of driving the pump at its rated speed and maximum pump load with a pressure as low as 80 psi (5.5 bar) at the turbine throttle when exhausting against atmospheric back pressure with the hand valve open.

10-1.2.2

For steam boiler pressures exceeding 120 psi (8 bar), where steam is continuously maintained, a pressure 70 percent of the usual boiler pressure shall take the place of the 80-psi (5.5-bar) pressure required in 10-1.2.1.

10-1.2.3

In ordering turbines for stationary fire pumps, the purchaser shall specify the rated and maximum pump loads at rated speed, the rated speed, the boiler pressure, the steam pressure at the turbine throttle (if possible), and the steam superheat.

10-1.3* Steam Consumption.

Prime consideration shall be given to the selection of a turbine having a total steam consumption commensurate with the steam supply available. Where multistage turbines are used, they shall be so designed that the pump can be brought up to speed without a warmup time requirement.

10-2 Turbine.

10-2.1 Casing and Other Parts.

10-2.1.1*

The casing shall be designed to permit access with the least possible removal of parts or piping.

10-2.1.2

A safety valve shall be connected directly to the turbine casing to relieve high steam pressure in the casing.

10-2.1.3

The main throttle valve shall be located in a horizontal run of pipe connected directly to the turbine. There shall be a water leg on the supply side of the throttle valve. This leg shall be connected to a suitable steam trap to automatically drain all condensate from the line supplying steam to the turbine. Steam and exhaust chambers shall be equipped with suitable condensate drains. Where the turbine is automatically controlled, these drains shall discharge through adequate traps. In addition, if the exhaust pipe discharges vertically, there shall be an open drain at the bottom elbow. This drain shall not be valved but shall discharge to a safe location.

10-2.1.4

The nozzle chamber, governor-valve body, pressure regulator, and other parts through which steam passes shall be made of a metal able to withstand the maximum temperatures involved.

10-2.2 Speed Governor.

10-2.2.1

The steam turbine shall be equipped with a speed governor set to maintain rated speed at maximum pump load. The governor shall be capable of maintaining, at all loads, the rated speed within a total range of approximately 8 percent from no turbine load to full-rated turbine load, by either of the following methods:

(1) With normal steam pressure and with hand valve closed

(2) With steam pressures down to 80 psi (5.5 bar) [or down to 70 percent of full pressure where this is in excess of 120 psi (8 bar)] and with hand valve open

10-2.2.2

While the turbine is running at rated pump load, the speed governor shall be capable of adjustment to secure speeds of approximately 5 percent above and 5 percent below the rated speed of the pump.

10-2.2.3

There shall also be provided an independent emergency governing device. It shall be arranged to shut off the steam supply at a turbine speed approximately 20 percent higher than the rated pump speed.

10-2.3 Gauge and Gauge Connections.

10-2.3.1

A listed steam pressure gauge shall be provided on the entrance side of the speed governor. A $^{1}/_{4}$-in. (6.4-mm) pipe tap for a gauge connection shall be provided on the nozzle chamber of the turbine.

10-2.3.2

The gauge shall indicate pressures not less than one and one-half times the boiler pressure, and in no case less than 240 psi (16 bar). The gauge shall be marked “Steam.”

10-2.4 Rotor.

The rotor of the turbine shall be of suitable material. The first unit of a rotor design shall be type tested in the manufacturer’s shop at 40 percent above rated speed. All subsequent units of the same design shall be tested at 25 percent above rated speed.

10-2.5 Shaft.

10-2.5.1

The shaft of the turbine shall be of high-grade steel, such as open-hearth carbon steel or nickel steel.

10-2.5.2

Where the pump and turbine are assembled as independent units, a flexible coupling shall be provided between the two units.

10-2.5.3

Where an overhung rotor is used, the shaft for the combined unit shall be in one piece with only two bearings.

10-2.5.4

The critical speed of the shaft shall be well above the highest speed of the turbine so that the turbine will operate at all speeds up to 120 percent of rated speed without objectionable vibration.

10-2.6 Bearings.

Turbines having sleeve bearings shall have split-type bearing shells and caps.

Exception: Turbines having ball bearings shall be acceptable after they have established a satisfactory record in the commercial field. Means shall be provided to give visible indication of the oil level.

10-3* Installation.

Details of steam supply, exhaust, and boiler feed shall be carefully planned to provide reliability and effective operation of a steam turbine-driven fire pump.

Chapter 11 Acceptance Testing, Performance, and Maintenance

11-1 Hydrostatic Tests and Flushing.

11-1.1

Suction and discharge piping shall be hydrostatically tested at not less than 200 psi (13.8 bar) pressure, or at 50 psi (3.4 bar) in excess of the maximum pressure to be maintained in the system, whichever is greater. The pressure shall be maintained for 2 hours.

11-1.2

Suction piping shall be flushed at a flow rate not less than indicated in Tables 11-1.2(a) and (b) or at the hydraulically calculated water demand rate of the system, whichever is greater.

Table 11-1.2(a) Flow Rate for Stationary Pumps

Pipe Size (in.)	Flow Rate	
	gpm	L/min
4	590	2,233
5	920	3,482
6	1,360	5,148
8	2,350	8,895
10	3,670	13,891
12	5,290	20,023

Table 11-1.2(b) Flush Rate for Suction Piping*

Table 11-1.2(b) Flush Rate for Suction Piping*

Pipe Size (in.)	Flow (gpm)
1 1/2	100
2	250
3	400
4	450
6	500

* For positive displacement pumps.

11-1.3

The installing contractor shall furnish a certificate of test prior to the start of the fire pump field acceptance test.

11-2 Field Acceptance Tests.

The pump manufacturer, the engine manufacturer (when supplied), the controller manufacturer, and the transfer switch manufacturer (when supplied) or their respective representatives shall be present for the field acceptance test. *(See Section 1-6.)*

11-2.1

All electric wiring to the fire pump motor(s), including control (multiple pumps) interwiring, emergency power supply, and jockey pump, shall be completed and checked by the electrical contractor prior to the initial startup and acceptance test.

11-2.2*

The authority having jurisdiction shall be notified as to time and place of the field acceptance test.

11-2.3

A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of results of field acceptance test. The fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test equipment.

11-2.4

The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.

11-2.5

Vibrations of the fire pump assembly shall not be of a magnitude to warrant potential damage to any fire pump component.

11-2.6* Field Acceptance Test Procedures.

11-2.6.1* Test Equipment.

Test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor-driven pumps, and speed.

11-2.6.2 Flow Tests.

11-2.6.2.1*

The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices.

Exception: If available suction supplies do not permit the flowing of 150 percent of rated pump capacity, the fire pump shall be operated at maximum allowable discharge to determine its acceptance. This reduced capacity shall not constitute an unacceptable test.

11-2.6.2.2

The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria. One performance point is required to establish positive displacement pump acceptability.

11-2.6.3* Measurement Procedure.

The quantity of water discharging from the fire pump assembly shall be determined and stabilized. Immediately thereafter, the operating conditions of the fire pump and driver shall be measured. Foam concentrate pumps shall be permitted to be tested with water; however, water flow rates can be lower than expected foam flow rates because of viscosity.

11-2.6.3.1

The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the foam concentrate tank or the inlet side of a water pump. The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data. If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction. Flow rates shall be as specified while operating at the system design pressure. Tests shall be performed in accordance with HI 3.6, *Rotary Pump Tests*.

11-2.6.3.2

For electric motors operating at rated voltage and frequency, the ampere demand shall not exceed the product of a full-load ampere rating times the allowable service factor as stamped on the motor nameplate.

11-2.6.3.3

For electric motors operating under varying voltage, the product of the actual voltage and current demand shall not exceed the product of the rated voltage and rated full-load current times the allowable service factor. The voltage at the motor shall not vary more than 5 percent below or 10 percent above rated (nameplate) voltage during the test. *(See Section 6-4.)*

11-2.6.3.4

Engine-driven units shall not show signs of overload or stress. The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed. *(See 8-2.4.1.)*

11-2.6.3.5

The steam turbine shall maintain its speed within the limits as specified in 10-2.2.

11-2.6.3.6

The gear drive assembly shall operate without excessive objectionable noise, vibration, or heating.

11-2.6.4 Loads Start Test.

The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.

11-2.6.5* Phase Reversal Test.

For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply (where provided).

11-2.7 Controller Acceptance Test.

11-2.7.1*

Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure. As a minimum, no less than six automatic and six manual operations shall be performed during the acceptance test.

11-2.7.2

A fire pump driver shall be operated for a period of at least 5 minutes at full speed during each of the operations required in 11-2.6.

Exception: An engine driver shall not be required to run for 5 minutes at full speed between successive starts until the cumulative cranking time of successive starts reaches 45 seconds.

11-2.7.3

The automatic operation sequence of the controller shall start the pump from all provided starting features. This sequence shall include pressure switches or remote starting signals.

11-2.7.4

Tests of engine-driven controllers shall be divided between both sets of batteries.

11-2.7.5

The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with this standard.

11-2.7.6

The fire pump shall be started once from each power service and run for a minimum of 5 minutes.

> **CAUTION:**
> Manual emergency operation shall be accomplished by a manual actuation of the emergency handle to the fully latched position in a continuous motion. The handle shall be latched for the duration of this test run.

11-2.8 Emergency Power Supply.

11-2.8.1

On installations with an emergency source of power and an automatic transfer switch, loss of primary source shall be simulated and transfer shall occur while the pump is operating at peak load. Transfer from normal to alternate source and retransfer from alternate to normal source shall not cause opening of overcurrent protection devices in either line. At least half of the manual and automatic operations of 11-2.7.1 shall be performed with the fire pump connected to the alternate source.

11-2.8.2

If the alternate power source is a generator set required by 6-2.3, installation acceptance shall be in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems*.

11-2.9 Emergency Governor.

Emergency governor valve for steam shall be operated to demonstrate satisfactory performance of the assembly. Hand tripping shall be acceptable.

11-2.10 Simulated Conditions.

Both local and remote alarm conditions shall be simulated to demonstrate satisfactory operation.

11-2.11 Test Duration.

The fire pump or foam concentrate pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

11-3 Manuals, Special Tools, and Spare Parts.

11-3.1

A minimum of one set of instruction manuals for all major components of the fire pump system shall be supplied by the manufacturer of each major component. The manual shall contain the following:

(1) A detailed explanation of the operation of the component

(2) Instructions for routine maintenance

(3) Detailed instructions concerning repairs

(4) Parts list and parts identification

(5) Schematic electrical drawings of controller, transfer switch, and alarm panels

11-3.2

Any special tools and testing devices required for routine maintenance shall be available for inspection by the authority having jurisdiction at the time of the field acceptance test.

11-3.3

Consideration shall be given to stocking spare parts for critical items not readily available.

11-4 Periodic Inspection, Testing, and Maintenance.

Fire pumps shall be inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

11-5 Component Replacement.

Whenever the moving components in a listed positive displacement fire pump are replaced, a field test of the pump shall be performed. If components that do not affect performance are replaced, such as shafts, then only a functional test shall be required to ensure proper installation and reassembly. If components that affect performance are replaced, such as rotors, plungers, and so forth, then a retest shall be conducted by the pump manufacturer or designated representative, or qualified person who is so designated by the appropriate authorities. The field retest results shall equal the original pump performance as indicated by the original factory-certified test curve, whenever it is available, and the results shall be within the accuracy limits of field testing as stated elsewhere in this standard.

Chapter 12 Referenced Publications

12-1

The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix C.

12-1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA

02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1998 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 1998 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 1999 edition.

NFPA 70, *National Electrical Code®*, 1999 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 1999 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1998 edition.

12-1.2 Other Publications.

12-1.2.1 AGMA Publication.

American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314-2730.

AGMA 390.03, *Handbook for Helical and Master Gears*, 1995.

12-1.2.2 ANSI Publications.

American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036.

ANSI/IEEE C62.1, *IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits*, 1989.

ANSI/IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits*, 1987.

ANSI/IEEE C62.41, *Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits, 1991*.

12-1.2.3 ASTM Publication.

American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 380, *Standard for Metric Practice*, 1991.

12-1.2.4 HI Publications.

Hydraulics Institute, 1230 Keith Building, Cleveland, OH 44115.

Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps, 14th ed., 1983.

HI 3.6, *Rotary Pump Tests,* 1994.

12-1.2.5 NEMA Publications.

National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209.

NEMA Industrial Control and Systems Standards, ICS 2.2, *Maintenance of Motor Controllers After a Fault Condition*, 1983.

NEMA MG-1, *Motors and Generators*, Parts 2 and 14, 1978.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-1

For more information, see NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and NFPA 70, *National Electrical Code®*, Article 695.

A-1-4

Because of the unique nature of fire pump units, the approval should be obtained prior to the assembly of any specific component.

A-1-6.1

A single entity should be designated as having unit responsibility for the pump, driver, controller, transfer switch equipment, and accessories. Unit responsibility means the accountability to answer and resolve any and all problems regarding the proper installation, compatibility, performance, and acceptance of the equipment. Unit responsibility should not be construed to mean purchase of all components from a single supplier.

A-1-8 Approved.

The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-8 Authority Having Jurisdiction.

The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-8 Head.

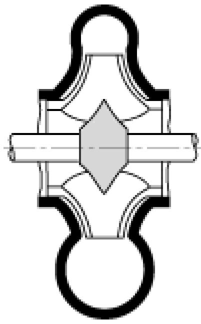
The unit for measuring head is the foot (meter). The relation between a pressure expressed in pounds per square inch (bar) and a pressure expressed in feet (meters) of head is expressed by the following formulas:

$$\text{head in feet} = \frac{\text{pressure in psi}}{0.433 \text{ specific gravity}}$$

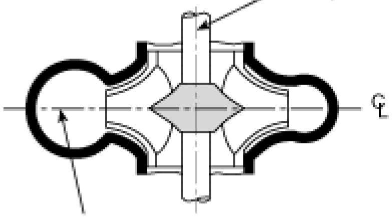
$$\text{head in meters} = \frac{\text{pressure in bar}}{0.098 \text{ specific gravity}}$$

In terms of foot-pounds (meter-kilograms) of energy per pound (kilogram) of water, all head quantities have the dimensions of feet (meters) of water. All pressure readings are converted into feet (meters) of the water being pumped. *[See Figure A-1-8(a), parts (a) and (b).]*

Figure A-1-8(a) Datum elevation of various stationary pump designs.



(a) Horizontal double-suction pump



(b) Vertical double-suction pump

Notes:
1. For all types of horizontal shaft pumps (single-stage double-suction pump shown). Datum is same for multistage, single-(end) suction ANSI-type or any pump with a horizontal shaft.
2. For all types of vertical shaft pumps (single-stage vertical double-suction pump shown). Datum is same for single-(end) suction, in-line, or any pump with a vertical shaft.

A-1-8 Listed.

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets identified standards or has been tested and found suitable for a specified purpose.

A-1-8 Service.

For more information, see NFPA 70, *National Electrical Code*, Article 100.

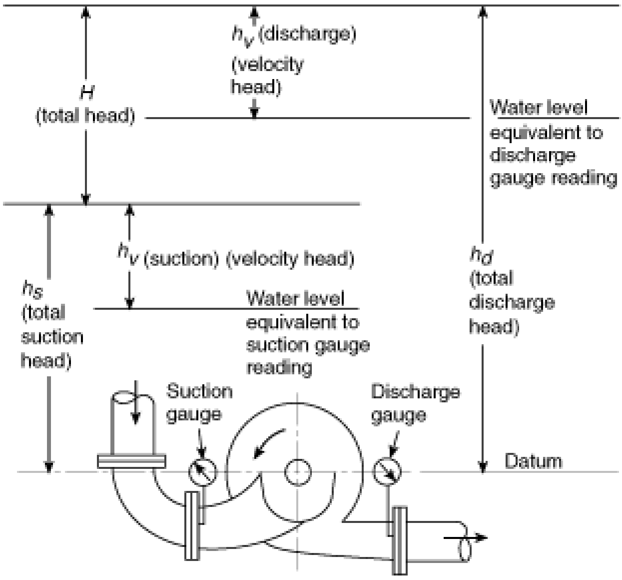
A-1-8 Service Equipment.

For more information, see NFPA 70, *National Electrical Code*, Article 100.

A-1-8 Total Head *(H)*, Horizontal Pumps.

See Figure A-1-8(b). Pictorial does not show the various types of pumps applicable.

Figure A-1-8(b) Total head of all types of stationary (not vertical turbine-type) fire pumps.



A-1-8 Total Head *(H)*, Vertical Turbine Pumps.

See Figure A-1-8(c).

A-1-8 Velocity Head *(h_v)*.

Velocity head is expressed by the following formula:

$$h_v = \frac{v^2}{2g}$$

Where

g = the acceleration due to gravity and is 32.17 ft/sec^2 (9.807 m/sec^2) at sea level and 45 degrees latitude

v = velocity in the pipe in ft/sec (m/sec)

A-2-1.1

For water supply capacity and pressure requirements, see the following documents:

(1) NFPA 13, *Standard for the Installation of Sprinkler Systems*

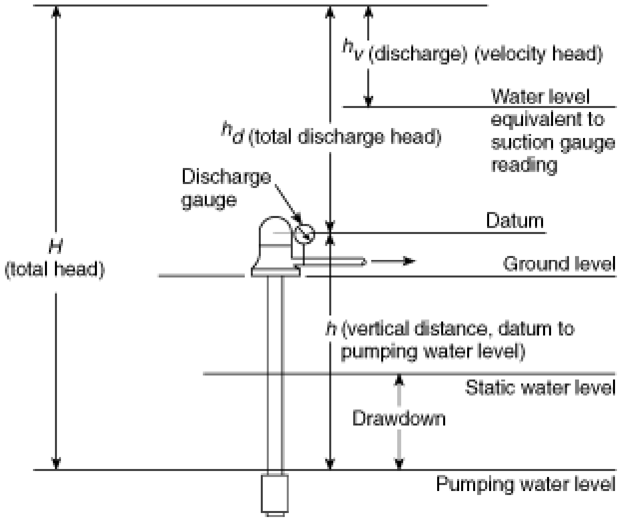
(2) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*

(3) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

(4) NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*

(5) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

Figure A-1-8(c) Total head of vertical turbine-type fire pumps.



A-2-1.2

Where the suction supply is from a factory-use water system, pump operation at 150 percent of rated capacity should not create hazardous process upsets due to low water pressure.

A-2-1.4

Water sources containing salt or other materials deleterious to the fire protection systems should be avoided.

A-2-2.4

It is poor design practice to overdesign the fire pump and driver and then count on the pressure relief valve to open and relieve the excess pressure. A pressure relief valve is not an acceptable method of reducing system pressure under normal operating conditions and should not be used as such.

A-2-3

A stationary pump for fire protection should be selected in the range of operation from 90 percent to 150 percent of its rated capacity. The performance of the pump when applied at capacities over 140 percent of rated capacity can be adversely affected by the suction conditions. Application of the pump at capacities less than 90 percent of the rated capacity is not recommended.

The selection and application of the fire pump should not be confused with pump operating conditions. With proper suction conditions, the pump can operate at any point on its characteristic curve from shutoff to 150 percent of its rated capacity.

A-2-5.2

For protection against damage from overpressure, where desired, a gauge protector should be installed.

A-2-7

Special consideration needs to be given to fire pump installations installed below grade. Light, heat, drainage, and ventilation are several of the variables that need to be addressed. Some locations or installations may not require a pump house. Where a pump room or pump house is required, it should be of ample size and located to permit short and properly arranged piping. The suction piping should receive first consideration. The pump house should preferably be a detached building of noncombustible construction. A one-story pump room with a combustible roof, either detached or well cut off from an adjoining one-story building, is acceptable if sprinklered. Where a detached building is not feasible, the pump room should be located and constructed so as to protect the pump unit and controls from falling floors or machinery and from fire that could drive away the pump operator or damage the pump unit or controls. Access to the pump room should be provided from outside the building. Where the use of brick or reinforced concrete is not feasible, metal lath and plaster is recommended for the construction of the pump room. The pump room or pump house should not be used for storage purposes. Vertical shaft turbine-type pumps can require a removable panel in the pump house roof to permit the pump to be removed for inspection or repair. Proper clearances to equipment should be provided as recommended by the manufacturer's drawings.

A-2-7.1

A fire pump that is inoperative for any reason at any time constitutes an impairment to the fire protection system. It should be returned to service without delay.

Rain and intense heat of the sun are adverse conditions to equipment not installed in a completely protective enclosure. At a minimum, equipment installed outdoors should be shielded by a roof or deck.

A-2-7.6

Pump rooms and pump houses should be dry and free of condensate. To accomplish a dry environment, heat can be required.

A-2-8.1

The exterior of aboveground steel piping should be kept painted.

A-2-8.2

Flanges welded to pipe are preferred.

A-2-8.4

When welding is performed on the pump suction or discharge piping with the pump in place, the welding ground should be on the same side of the pump as the welding.

A-2-9.1

The exterior of steel suction piping should be kept painted.

Buried iron or steel pipe should be lined and coated or protected against corrosion in conformance with applicable AWWA C104, *Cement-Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings for Water*, or equivalent standards.

A-2-9.4

The following notes apply to Figure A-2-9.4.

(1) A jockey pump is usually required with automatically controlled pumps.

(2) If testing facilities are to be provided, also see Figures A-2-14.1.2(a) and (b).

(3) Pressure-sensing lines also need to be installed in accordance with 7-5.2.1 or 9-5.2.1. See Figures A-7-5.2.1(a) and (b).

A-2-9.5

Where the suction supply is from public water mains, the gate valve should be located as far as is practical from the suction flange on the pump. Where it comes from a stored water container, the gate valve should be located at the outlet of the container. A butterfly valve on the suction side of the pump can create turbulence that adversely affects the pump performance and can increase the possibility of blockage of the pipe.

A-2-9.6

See Figure A-2-9.6. *(See Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps for additional information.)*

Figure A-2-9.4 Schematic diagram of suggested arrangements for a fire pump with a bypass, taking suction from public mains.

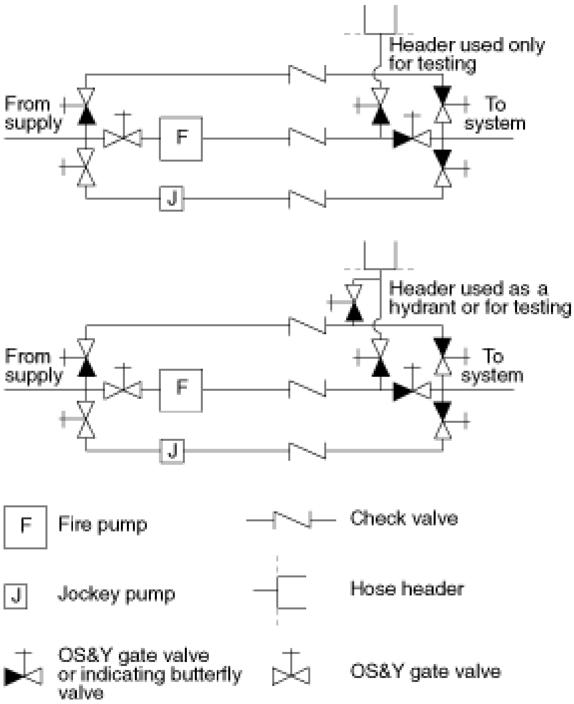
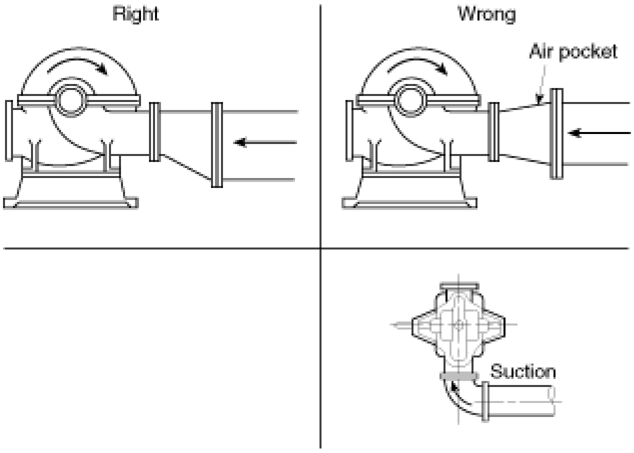


Figure A-2-9.6 Right and wrong pump suctions.



A-2-9.8

When selecting screen material, consideration should be given to prevention of fouling from aquatic growth. Antifouling is best accomplished with brass or copper wire.

A-2-9.9

The term *device* as used in this subsection is intended to include, but not be limited to, devices that sense suction pressure and then restrict or stop the fire pump discharge. Due to the pressure losses and the potential for interruption of the flow to the fire protection systems, the use of backflow prevention devices is discouraged in fire pump piping. Where required, however, the placement of such a device on the discharge side of the pump is to ensure acceptable flow characteristics to the pump suction. It is more efficient to lose the pressure after the pump has boosted it, rather than before the pump has boosted it. Where the backflow preventer is on the discharge side of the pump and a jockey pump is installed, the jockey pump discharge and sensing lines need to be located so that a cross-connection is not created through the jockey pump.

A-2-9.10

For more information, see the *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.*

A-2-10.2

Flanges welded to the pipe are preferred.

A-2-10.3

The discharge pipe size should be such that, with the pump(s) operating at 150 percent of rated capacity, the velocity in the discharge pipe does not exceed 20 ft/sec (6.2 m/sec).

A-2-10.4

Large fire protection systems sometimes experience severe water hammer caused by backflow when the automatic control shuts down the fire pump. Where conditions can be expected to cause objectionable water hammer, a listed anti-water-hammer check valve should be installed in the discharge line of the fire pump. Automatically controlled pumps in tall buildings could give trouble from water hammer as the pump is shutting down.

Where a backflow preventer is substituted for the discharge check valve, an additional backflow preventer can be necessary in the bypass piping to prevent backflow through the bypass.

Where a backflow preventer is substituted for the discharge check valve, the connection for the sensing line is permitted to be between the last check valve and the last control valve if the pressure-sensing line connection can be made without altering the backflow valve or violating its listing. This method can sometimes be done by adding a connection through the test port on the backflow valve. In this situation, the discharge control valve is not necessary, since the last control valve on the backflow preventer serves this function.

Where a backflow preventer is substituted for the discharge check valve and the connection of the sensing line cannot be made within the backflow preventer, the sensing line should be connected between the backflow preventer and the pump's discharge control valve. In this situation, the backflow preventer cannot substitute for the discharge control valve because the sensing line needs to be capable of being isolated.

A-2-11

Isolation valves and control valves are considered to be identical when used in conjunction with a backflow prevention assembly.

A-2-12

Pipe breakage caused by movement can be greatly lessened and, in many cases, prevented by increasing flexibility between major parts of the piping. One part of the piping should never be held rigidly and another free to move, without provisions for relieving the strain. Flexibility can be provided by the use of flexible couplings at critical points and by allowing clearances at walls and floors. Fire pump suction and discharge pipes should be treated the same as sprinkler risers for whatever portion is within a building. *(See NFPA 13, Standard for the Installation of Sprinkler Systems.)*

Holes through pump room fire walls should be packed with mineral wool or other suitable material held in place by pipe collars on each side of the wall. Pipes passing through foundation walls or pit walls into ground should have clearance from these walls, but holes should be watertight. Space around pipes passing through pump room walls or pump house floors can be filled with asphalt mastic.

A-2-13.1

The pressure is required to be evaluated at 121 percent 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 percent, creating a pressure of 121 percent. Since the only time that a pressure relief valve is required by the standard to be installed is where the diesel engine is turning faster than normal, and since this is a relatively rare event, it is permitted for the discharge from the pressure relief valve to be piped back to the suction side of the pump.

A-2-13.5

The relief valve cone should be piped to a point where water can be freely discharged, preferably outside the building. If the relief valve discharge pipe is connected to an underground drain, care should be taken that no steam drains enter near enough to work back through the cone and into the pump room.

A-2-13.7

Where the relief valve discharges back to the source of supply, the back pressure capabilities and limitations of the valve to be used should be determined. It can be necessary to increase the size of the relief valve and piping above the minimum to obtain adequate relief capacity due to back pressure restriction.

A-2-13.8

When discharge enters the reservoir below minimum water level, there is not likely to be an air problem. If it enters over the top of the reservoir, the air problem is reduced by extending the discharge to below the normal water level.

A-2-14.1.2

Outlets can be provided through the use of standard test headers, yard hydrants, wall hydrants, or standpipe hose valves.

The following notes apply to Figures A-2-14.1.2(a) and (b).

(1) Distance as recommended by the meter manufacturer.

(2) Distance not less than 5 diameters of suction pipe for top or bottom suction connection. Distance not less than 10 diameters of suction pipe for side connection (not recommended).

(3) Automatic air release if piping forms an inverted “U,” trapping air.

(4) The fire protection system should have outlets available to test the fire pump and suction supply piping. *(See A-2-14.3.1.)*

(5) The closed loop meter arrangement will only test net pump performance. It does not test the condition of the suction supply, valves, piping, and so forth.

(6) Return piping should be so arranged that no air can be trapped that would eventually end up in the eye of the pump impeller.

(7) Turbulence in the water entering the pump should be avoided to eliminate cavitation that would reduce pump discharge and damage the pump impeller. For this reason, side connection is not recommended.

(8) Prolonged recirculation can cause damaging heat buildup, unless some water is wasted.

(9) Flowmeter should be installed according to manufacturer's instructions.

(10) Pressure-sensing lines also need to be installed in accordance with 7-5.2.1. *[See Figures A-7-5.2.1(a) and (b).]*

Figure A-2-14.1.2(a) Preferred arrangement for measuring fire pump water flow with meter for multiple pumps and water supplies. Water is permitted to discharge to a drain or to the fire pump water source.

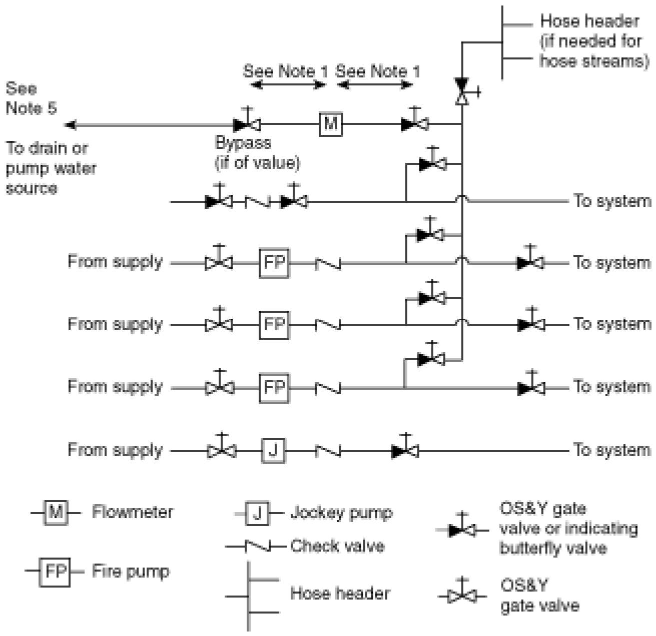
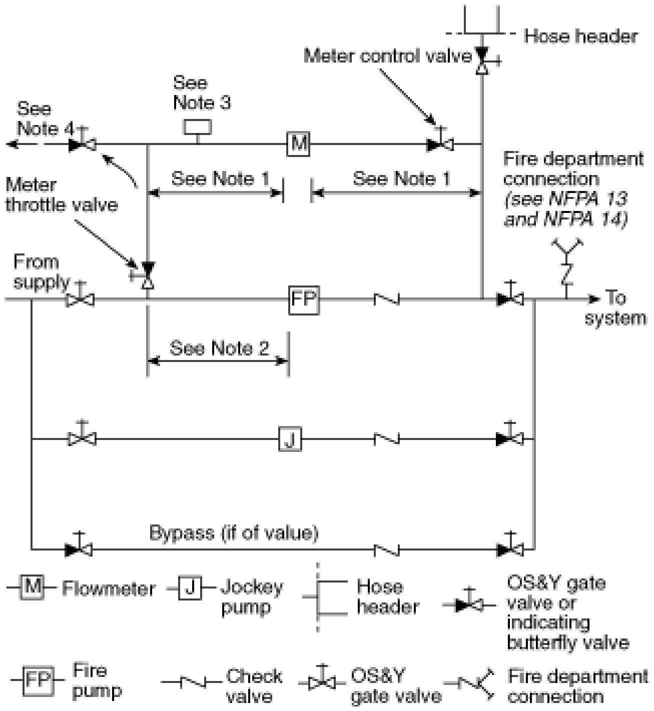


Figure A-2-14.1.2(b) Typical arrangement for measuring fire pump water flow with meter. Discharge from the flowmeter is recirculated to the fire pump suction line.



A-2-14.2.1

Metering devices should discharge to drain.

Exception: In the case of a limited water supply, the discharge should be back to the water source (e.g., suction tank, small pond, etc.). If this discharge enters the source below minimum water level, it is not likely to create an air problem for the pump suction. If it enters over the top of the source, the air problem is reduced by extending the discharge to below the normal water level.

A-2-14.3.1

The hose valves should be attached to a header or manifold and connected by suitable piping to the pump discharge piping. The connection point should be between the discharge check valve and the discharge gate valve. Hose valves should be located to avoid any possible water damage to the pump driver or controller, and they should be outside the pump room or pump house. If there are other adequate pump testing facilities, the hose valve header can be omitted when its main function is to provide a method of pump and suction supply testing. Where the hose header also serves as the equivalent of a yard hydrant, this omission should not reduce the number of hose valves to less than two.

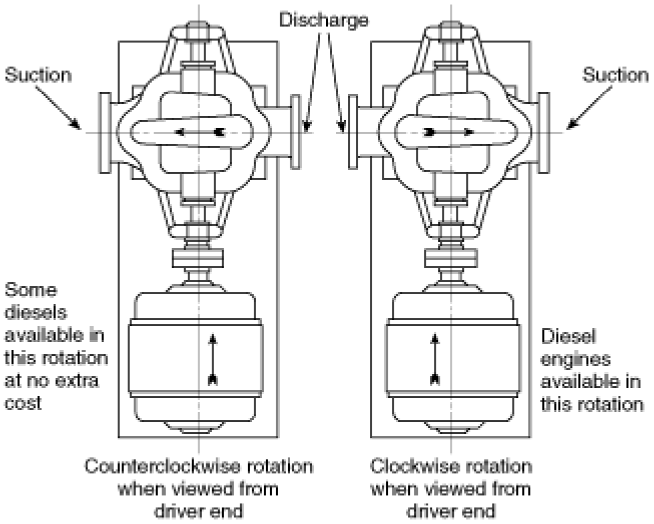
A-2-17

Pump shaft rotation can be determined as follows.

(a) *Rotation of Pumps.* Pumps are designated as having right-hand [or clockwise (CW)] rotation, or left-hand [or counterclockwise (CCW)] rotation. Diesel engines are commonly stocked and supplied with clockwise rotation.

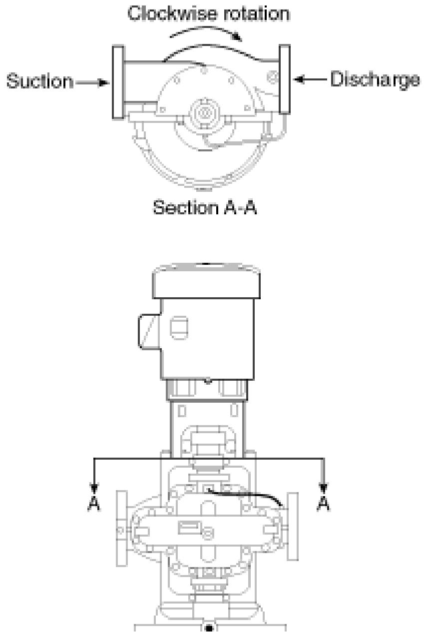
(b) *Horizontal Pump Shaft Rotation.* The rotation of a horizontal pump can be determined by standing at the driver end and facing the pump. *[See Figure A-2-17(b).]* If the top of the shaft revolves from the left to the right, the rotation is right-handed [or clockwise (CW)]. If the top of the shaft revolves from right to left, the rotation is left-handed [or counterclockwise (CCW)].

Figure A-2-17(b) Horizontal pump shaft rotation.



(c) *Vertical Pump Shaft Rotation.* The rotation of a vertical pump can be determined by looking down upon the top of the pump. *[See Figure A-2-17(c).]* If the point of the shaft directly opposite revolves from left to right, the rotation is right-handed [or clockwise (CW)]. If the point of the shaft directly opposite revolves from right to left, the rotation is left-handed [or counterclockwise (CCW)].

Figure A-2-17(c) Vertical pump shaft rotation.



In addition to those conditions that require alarm signals for pump controllers and engines, there are other conditions for which such alarms could be recommended, depending upon local conditions. Some of these supervisory alarm conditions are as follows:

(1) Low pump room temperature

(2) Relief valve discharge

(3) Flowmeter left on, bypassing the pump

(4) Water level in suction supply below normal

(5) Water level in suction supply near depletion

(6) Diesel fuel supply below normal

(7) Steam pressure below normal

Such additional alarms can be incorporated into the trouble alarms already provided on the controller, or they can be independent.

A-2-19

Pressure maintenance (jockey or make-up) pumps should be used where it is desirable to maintain a uniform or relatively high pressure on the fire protection system. A jockey pump should be sized to make up the allowable leakage rate within 10 minutes or 1 gpm (3.8 L/min), whichever is larger.

A-2-19.3

See Figure A-2-19.3.

A-2-19.4

A centrifugal-type pressure maintenance pump is preferable.

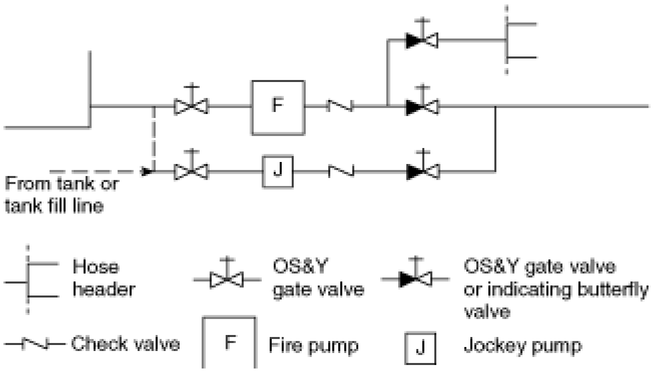
The following notes apply to a centrifugal-type pressure maintenance pump.

(1) A jockey pump is usually required with automatically controlled pumps.

(2) Jockey pump suction can come from the tank filling supply line. This situation would allow high pressure to be maintained on the fire protection system even when the supply tank is empty for repairs.

(3) Pressure-sensing lines also need to be installed in accordance with 7-5.2.1. *[See Figures A-7-5.2.1(a) and (b).]*

Figure A-2-19.3 Jockey pump installation with fire pump.



A-2-22.1

NFPA 13, *Standard for the Installation of Sprinkler Systems*, contains specific guidance for seismic design of fire protection systems. Tables are available to determine the relative strength of many common bracing materials and fasteners.

A-3-1.1

See Figures A-3-1.1(a) through (h).

Figure A-3-1.1(a) Overhung impeller — close coupled single stage — end suction.

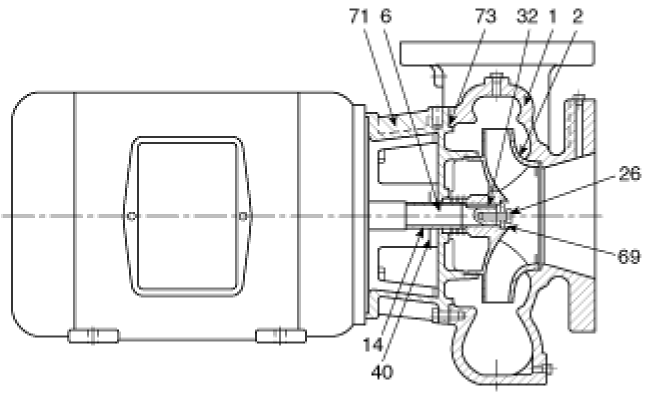
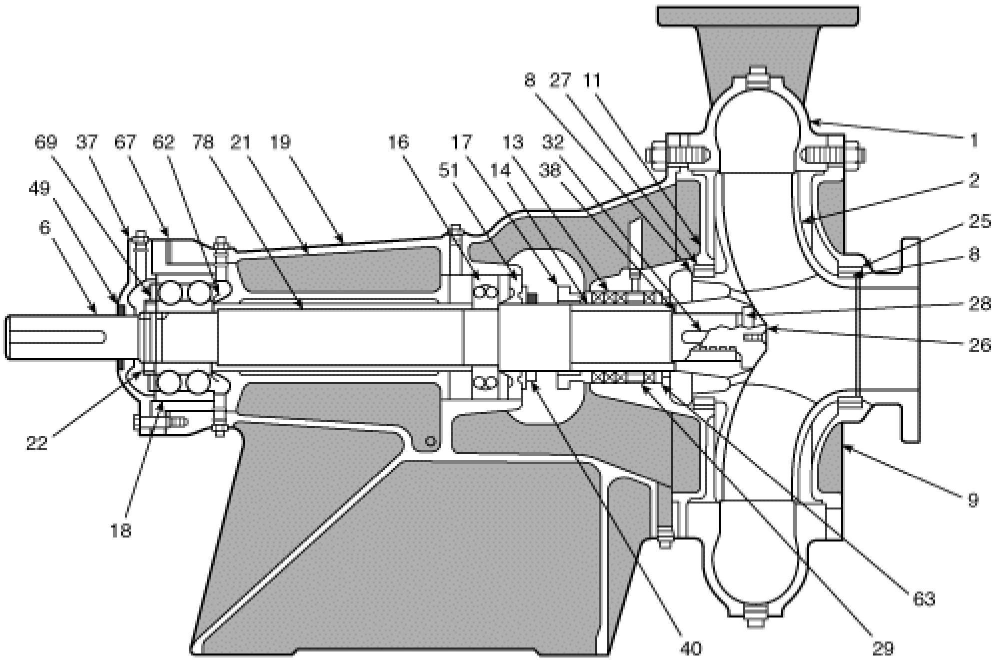
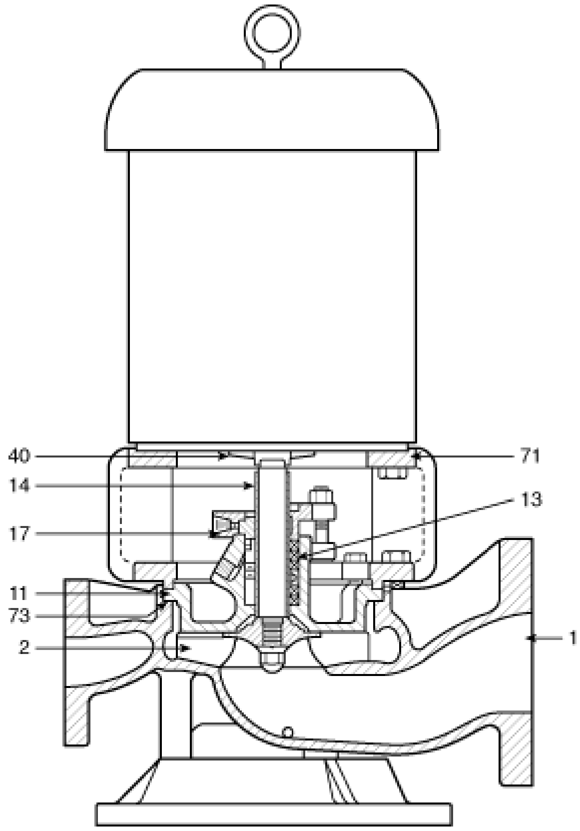


Figure A-3-1.1(b) Overhung impeller — separately coupled single stage — frame mounted.



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

Figure A-3-1.1(c) Overhung impeller — close coupled single stage — in-line (showing seal and packaging).



1 Casing
2 Impeller
11 Cover, seal chamber
13 Packing
14 Sleeve, shaft
17 Gland, packing
40 Deflector
71 Adapter
73 Gasket, casing

Figure A-3-1.1(d) Overhung impeller — separately coupled single stage — in-line — rigid coupling.

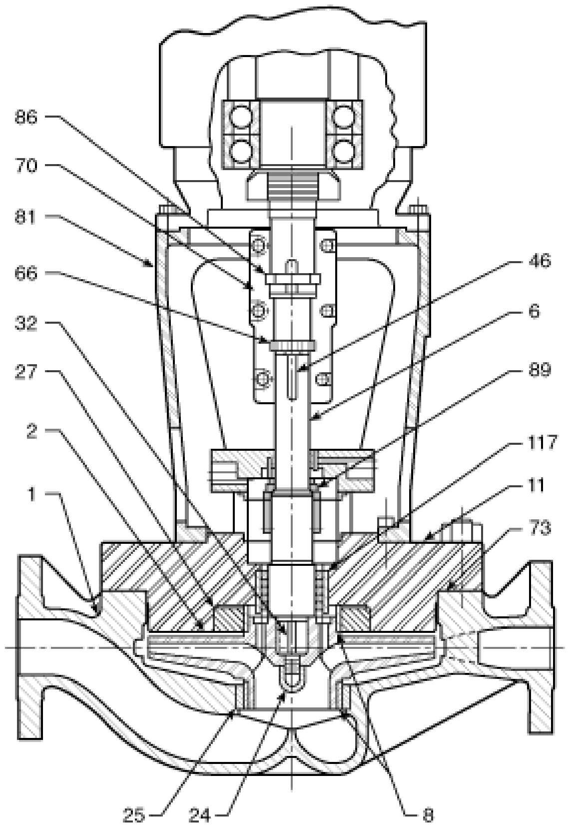
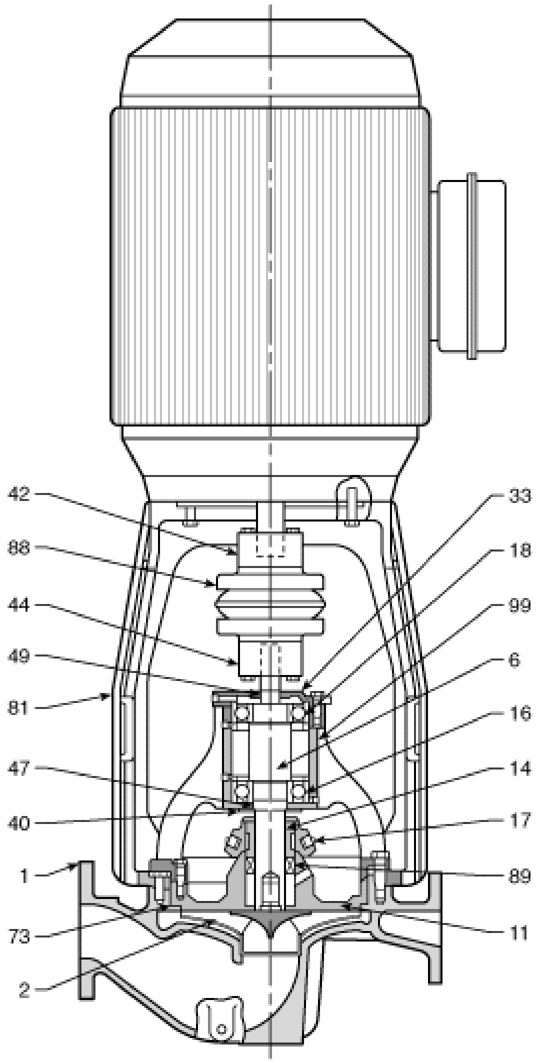
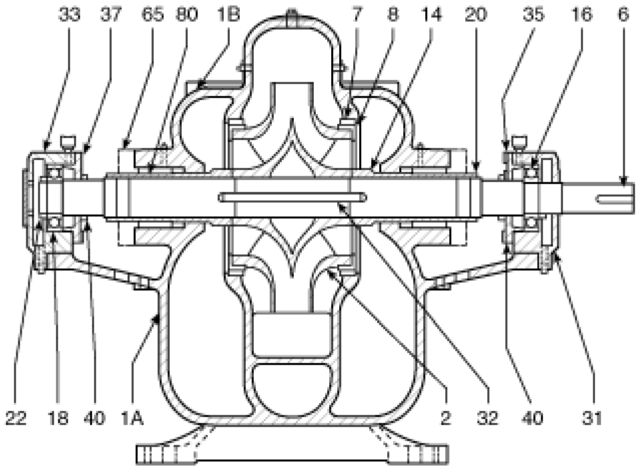


Figure A-3-1.1(e) Overhung impeller — separately coupled single stage — in-line — flexible coupling.



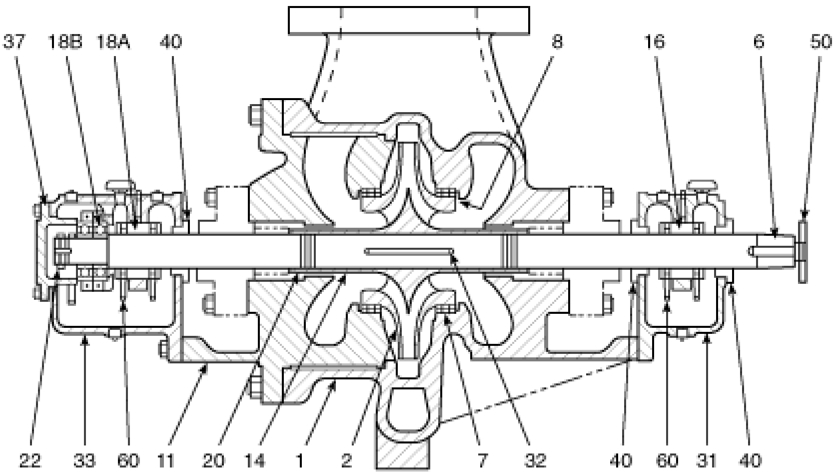
1 Casing
2 Impeller
6 Shaft, pump
11 Cover, seal chamber
14 Sleeve, shaft
16 Bearing, inboard
17 Gland
18 Bearing, outboard
33 Cap, bearing, outboard
40 Deflector
42 Coupling half, driver
44 Coupling half, pump
47 Seal, bearing cover, inboard
49 Seal, bearing cover, outboard
73 Gasket
81 Pedestal, driver
88 Spacer, coupling
89 Seal
99 Housing, bearing

Figure A-3-1.1(f) Impeller between bearings — separately coupled — single stage — axial (horizontal) split case.



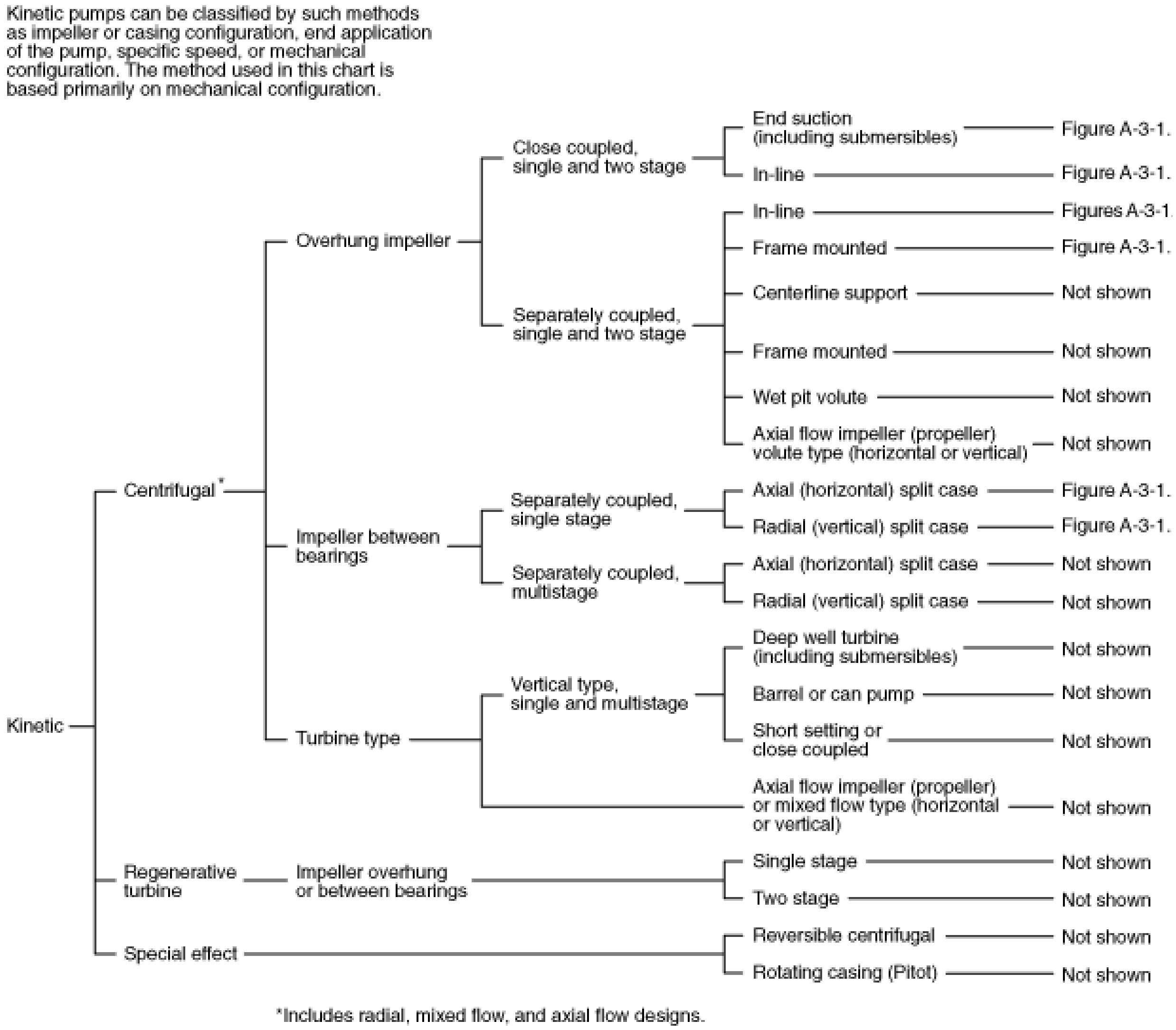
1A Casing, lower half
1B Casing, upper half
2 Impeller
6 Shaft
7 Ring, casing
8 Ring, impeller
14 Sleeve, shaft
16 Bearing, inboard
18 Bearing, outboard
20 Nut, shaft sleeve
22 Locknut
31 Housing, bearing inboard
32 Key, impeller
33 Housing, bearing outboard
35 Cover, bearing inboard
37 Cover, bearing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

Figure A-3-1.1(g) Impeller between bearings — separately coupled — single stage — radial (vertical) split case.



1 Casing
2 Impeller
6 Shaft
7 Ring, casing
8 Ring, impeller
11 Cover, stuffing-box
14 Sleeve, shaft
16 Bearing, inboard, sleeve
18A Bearing, outboard, sleeve
18B Bearing, outboard, ball
20 Nut, shaft sleeve
22 Locknut, bearing
31 Housing, bearing, inboard
32 Key, impeller
33 Housing, bearing, outboard
37 Cover, bearing, outboard
40 Deflector
50 Locknut, coupling
60 Ring, oil

Figure A-3-1.1(h) Types of stationary pumps.



A-3-1.2

The centrifugal pump is particularly suited to boost the pressure from a public or private supply or to pump from a storage tank where there is a positive static head.

A-3-2

Listed pumps can have different head capacity curve shapes for a given rating. Figure A-3-2 illustrates the extremes of the curve shapes probable. Shutoff head will range from a minimum of 101 percent to a maximum of 140 percent of rated head. At 150 percent of rated capacity, head will range from a minimum of 65 percent to a maximum of just below rated head. Pump manufacturers can supply expected curves for their listed pumps.

A-3-3.1

See Figure A-3-3.1.

A-3-4.1

Flexible couplings are used to compensate for temperature changes and to permit end movement of the connected shafts without interfering with each other.

A-3-4.3

A substantial foundation is important in maintaining alignment. The foundation preferably should be made of reinforced concrete.

Figure A-3-2 Pump characteristics curves.

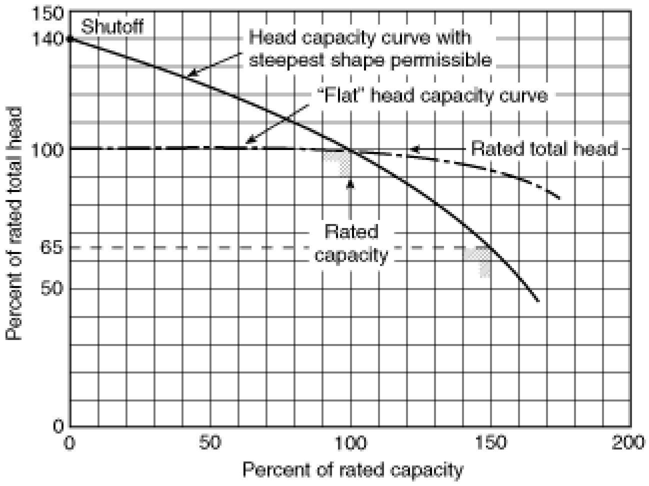
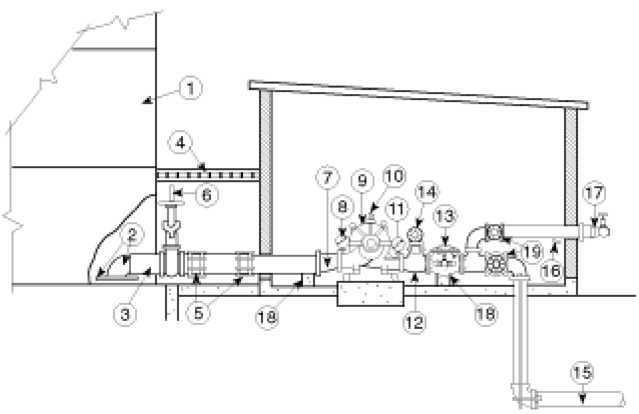


Figure A-3-3.1 Horizontal split-case fire pump installation with water supply under a positive head.



1 Aboveground suction tank
2 Entrance elbow and square steel vortex plate with dimensions at least twice the diameter of the suction pipe. Distance above the bottom of tank is one-half the diameter of the suction pipe with minimum of 6 in. (152 mm).
3 Suction pipe
4 Frostproof casing
5 Flexible couplings for strain relief
6 OS&Y gate valve *(see 2-9.5 and A-2-9.5)*
7 Eccentric reducer
8 Suction gauge
9 Horizontal split-case fire pump
10 Automatic air release
11 Discharge gauge
12 Reducing discharge tee
13 Discharge check valve
14 Relief valve (if required)
15 Supply pipe for fire protection system
16 Drain valve or ball drip
17 Hose valve manifold with hose valves
18 Pipe supports
19 Indicating gate or indicating butterfly valve

A-3-5

If pumps and drivers were shipped from the factory with both machines mounted on a common base plate, they were accurately aligned before shipment. All base plates are flexible to some extent and, therefore, should not be relied upon to maintain the factory alignment. Realignment is necessary after the complete unit has been leveled on the foundation and again after the grout has set and foundation bolts have been tightened. The alignment should be checked after the unit is piped and rechecked periodically. To facilitate accurate field alignment, most manufacturers either do not dowel the pumps or drivers on the base plates before shipment, or at most dowel the pump only.

After the pump and driver unit has been placed on the foundation, the coupling halves should be disconnected. The coupling should not be reconnected until the 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.

The two forms of misalignment between the pump shaft and the driver shaft are as follows.

(a) *Angular Misalignment*. Shafts with axes concentric but not parallel.

(b) *Parallel Misalignment*. Shafts with axes parallel but not concentric.

The faces of the coupling halves should be spaced within the manufacturer's recommendations and far enough apart so that they cannot strike each other when the driver rotor is moved hard over toward the pump. Due allowance should be made for wear of the thrust bearings. The necessary tools for an approximate check of the alignment of a flexible coupling are a straight edge and a taper gauge or a set of feeler gauges.

A check for angular alignment is made by inserting the taper gauge 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. *[See Figure A-3-5(a).]* The unit will be in angular alignment when the measurements show that 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. *[See Figure A-3-5(b).]* The unit 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 should be taken to have the straight edge parallel to the axes of the shafts.

Angular and parallel misalignment are corrected by means of shims under the motor mounting feet. After each change, it is necessary to recheck the alignment of the coupling halves. Adjustment in one direction can disturb adjustments already made in another direction. It should not be necessary to adjust the shims under the pump.

The permissible amount of misalignment will vary with the type of pump, driver, and coupling manufacturer, model, and size.

The best method for putting the coupling halves in final accurate alignment is by the use of a dial indicator.

When the alignment is correct, the foundation bolts should be tightened evenly but not too firmly. The unit can then be grouted to the foundation. The base plate should be completely filled with grout, and it is desirable to grout the leveling pieces, shims, or wedges in place. Foundation bolts should not 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, the unit should be checked for parallel and angular alignment, and, if necessary, corrective measures taken. After the piping of the unit has been connected, the alignment should be checked again.

The direction of driver rotation should be checked to make certain that 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 unit then should be operated under normal operating conditions until temperatures have stabilized. It then should be shut down and immediately checked again for alignment of the coupling. All alignment checks should be made with the coupling halves disconnected and again after they are reconnected.

After the unit has been in operation for about 10 hours or 3 months, the coupling halves should be given a final check for misalignment caused by pipe or temperature strains. If the alignment is correct, both pump and driver should be dowelled to the base plate. Dowel location is very important and the manufacturer's instructions should be obtained, especially if the unit is subjected to temperature changes.

Figure A-3-5(a) Checking angular alignment. ***(Courtesy of Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.)***

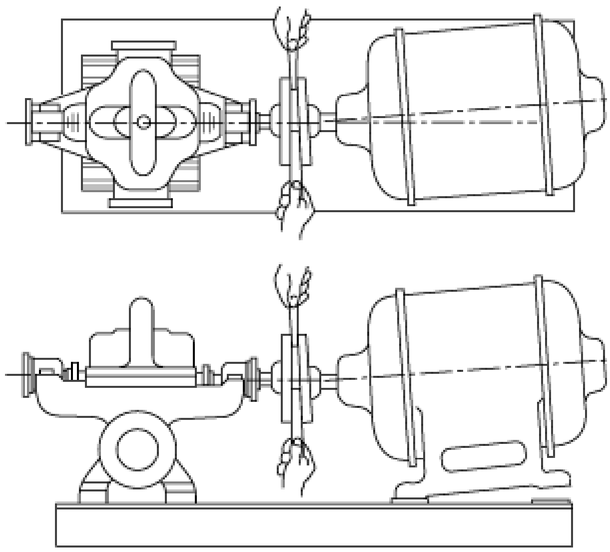
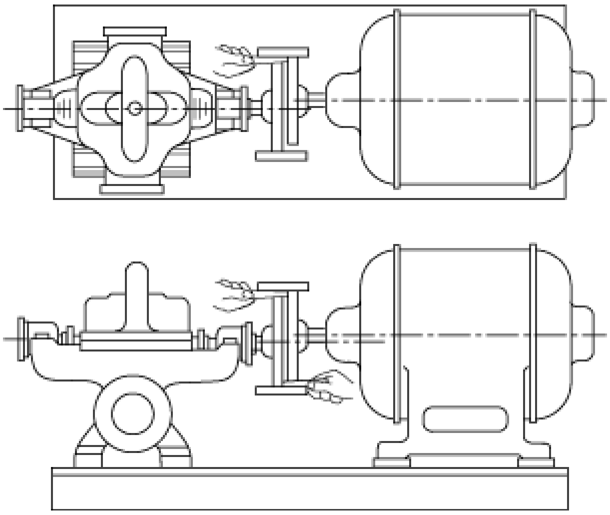


Figure A-3-5(b) Checking parallel alignment. ***(Courtesy of Hydraulics Institute***

Standards for Centrifugal, Rotary and Reciprocating Pumps.)



The unit should be checked periodically for alignment. If the unit does not stay in line after being properly installed, the following are possible causes:

(1) Settling, seasoning, or springing of the foundation and pipe strains distorting or shifting the machine

(2) Wearing of the bearings

(3) Springing of the base plate by heat from an adjacent steam pipe or from a steam turbine

(4) Shifting of the building structure due to variable loading or other causes

(5) It can be necessary to slightly readjust the alignment from time to time, while the unit and foundation are new.

A-4-1

Satisfactory operation of vertical turbine-type pumps is dependent to a large extent upon careful and correct installation of the unit; therefore, it is recommended that this work be done under the direction of a representative of the pump manufacturer.

A-4-1.1

The vertical shaft turbine-type pump is particularly suitable for fire pump service where the water source 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 permitted to be used to lift water from lakes, streams, open swamps, and other subsurface sources. Both oil-lubricated enclosed-line-shaft and waterlubricated open-line-shaft pumps are used. *(See Figure A-4-1.1.)* Some health departments object to the use of oil-lubricated pumps; such authorities should be consulted before proceeding with oil-lubricated design.

A-4-2.1.1

Stored water supplies from reservoirs or tanks supplying wet pits are preferable. Lakes, streams, and groundwater supplies are acceptable where investigation shows that they can be expected to provide a suitable and reliable supply.

A-4-2.1.2

The authority having jurisdiction can require an aquifer performance analysis. The history of the water table should be carefully investigated. The number of wells already in use in the area and the probable number that can be in use should be considered in relation to the total amount of water available for fire protection purposes.

A-4-2.2.1

See Figure A-4-2.2.1.

A-4-2.2.2

The velocities in the approach channel or intake pipe should not exceed approximately 2 ft/sec (0.7 m/sec), and the velocity in the wet pit should not exceed approximately 1 ft/sec (0.3 m/sec). *(See Figure A-4-2.2.2.)*

The ideal approach is a straight channel coming directly to the pump. Turns and obstructions are detrimental since they can cause eddy currents and tend to initiate deep-cored vortices. The amount of submergence for successful operation will depend greatly on the approaches of the intake and the size of the pump.

The *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps* has recommended sump dimensions for flows 3000 gpm (11,355 L/min) and larger. The design of sumps for pumps with discharge capacities less than 3000 gpm (11,355 L/min) should be guided by the same general principles as shown in the *Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*.

Figure A-4-1.1 Illustration of water-lubricated and oil-lubricated shaft pumps.

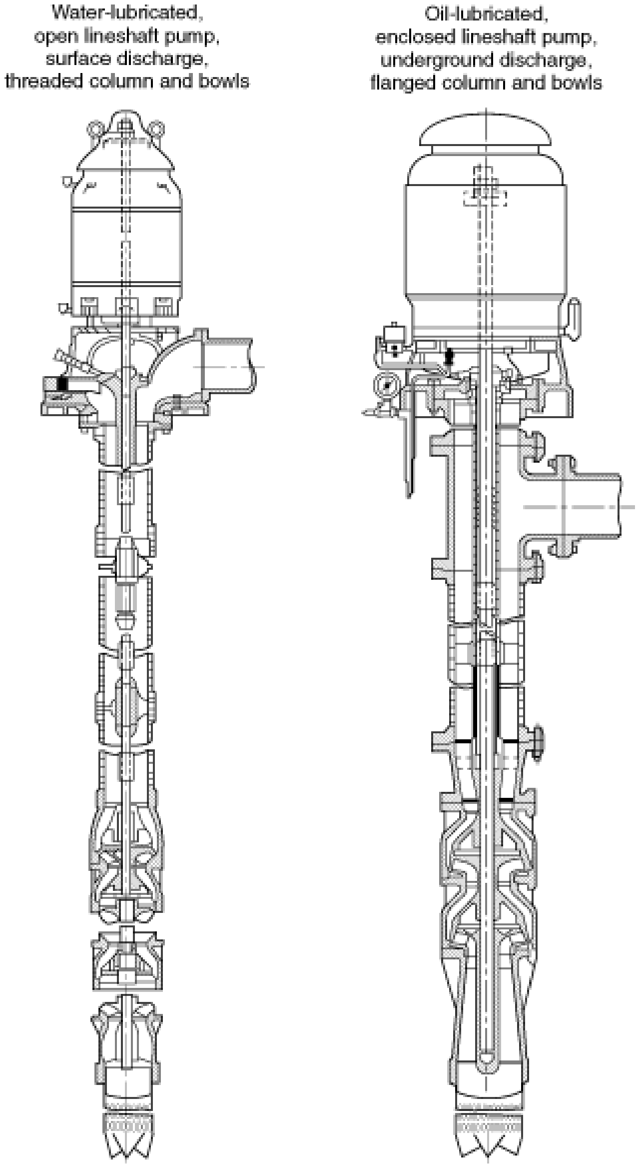


Figure A-4-2.2.1 Vertical shaft turbine-type pump installation in a well.

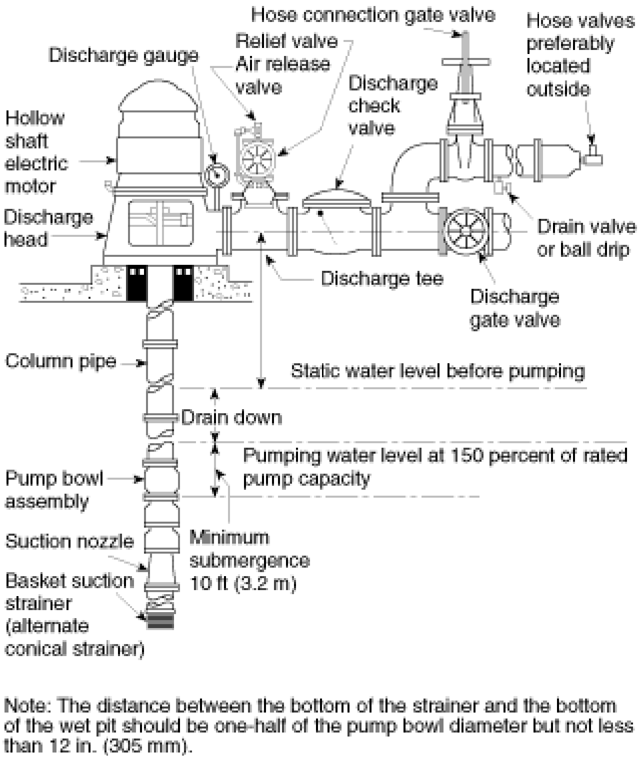
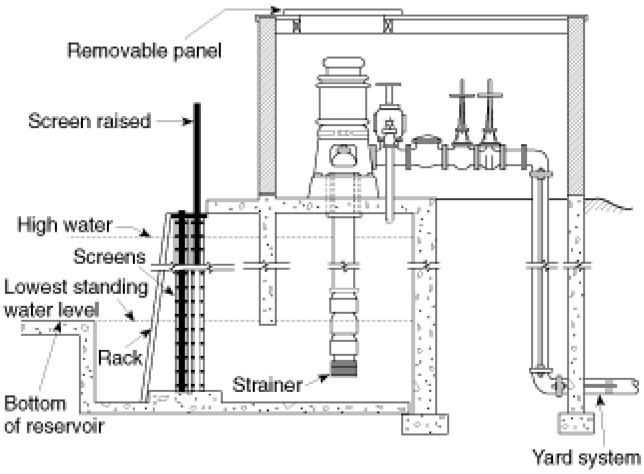


Figure A-4-2.2.2 Vertical shaft turbine-type pump installation in a wet pit.



A-4-2.5

Where wells take their supply from consolidated formations such as rock, the specifications for the well should be decided upon by the authority having jurisdiction after consultation with a recognized groundwater consultant in the area.

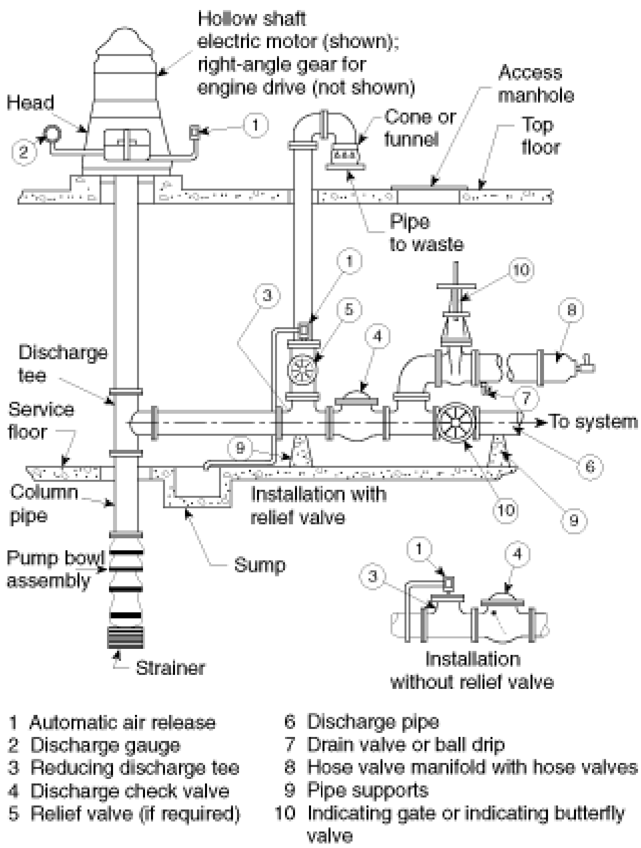
A-4-2.7

Before the permanent pump is ordered, the water from the well should be analyzed for corrosiveness, including such items as pH, salts such as chlorides, and harmful gases such as carbon dioxide (CO_2) or hydrogen sulfide (H_2S). If the water is corrosive, the pumps should be constructed of a suitable corrosion-resistant material or covered with special protective coatings in accordance with the manufacturers' recommendations.

A-4-3.1

See Figure A-4-3.1.

Figure A-4-3.1 Belowground discharge arrangement.



A-4-3.5.3

Water level detection using the air line method is as follows.

(a) A satisfactory method of determining the water level involves the use of an air line of small pipe or tubing and of known vertical length, a pressure or depth gauge, and an ordinary bicycle or automobile pump installed as shown in Figure A-4-3.5.3. The air line pipe should be of known length and extend beyond the lowest anticipated water level in the well in order to ensure more reliable gauge readings, and should be properly installed. As noted in Figure A-4-3.5.3, an air pressure gauge is used to indicate the pressure in the air line.

(b) The air line pipe is lowered into the well, a tee is placed in the line above the ground, and a pressure gauge is screwed into one connection. The other connection is fitted with an ordinary bicycle valve to which a bicycle pump is attached. All joints should be made carefully and should be airtight to obtain correct information. When air is forced into the line by means of the bicycle pump, the gauge pressure increases until all of the water has been expelled. When this point is reached, the gauge reading becomes constant. The maximum maintained air pressure recorded by the gauge is equivalent to that necessary to support a column of water of the same height as that forced out of the air line. The length of this water column is equal to the amount of air line submerged.

(c) Deducting this pressure converted to feet (m) (psi pressure × 2.31 = ft and bar pressure × 10.3 = m) from the known length of the air line will give the amount of submergence.

Example: The following calculation will serve to clarify Figure A-4-3.5.3.

Assume a length (L) of 50 ft (15.2 m).

Pressure gauge reading before starting fire pump (p_1) = 10 psi (0.68 bar). Then A = 10 × 2.31 = 23.1 ft (0.68 × 10.3 = 7.0 m). Therefore, the water level in the well before starting the pump would be $B = L - A$ = 50 ft - 23.1 ft = 26.9 ft ($B = L - A$ = 15.2 m - 7 m = 8.2 m).

Pressure gauge reading when pumping (p_2) = 8 psi (0.55 bar). Then C = 8 × 2.31 = 18.5 ft (0.55 × 10.3 = 5.6 m). Therefore, the water level in the well while pumping would be $D = L - C$ = 50 ft - 18.5 ft = 31.5 ft ($D = L - C$ = 15.2 m - 5.6 m = 9.6 m).

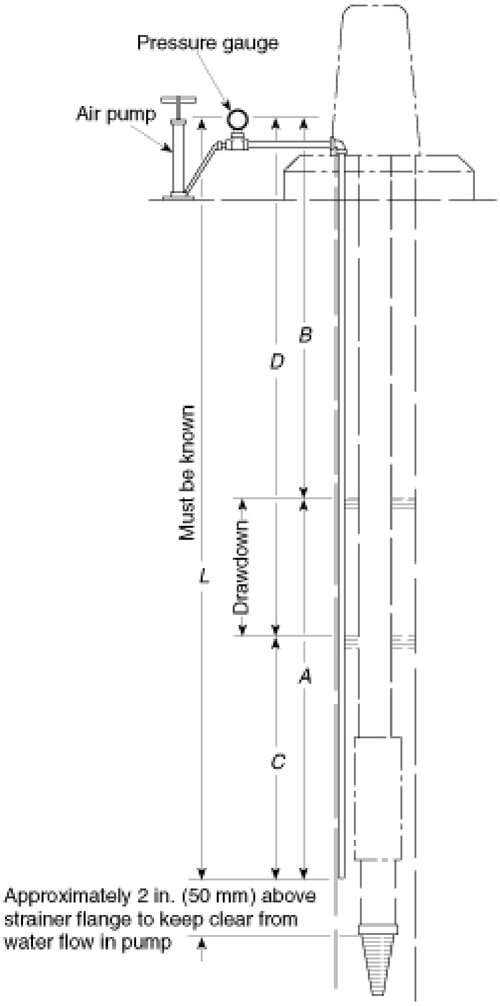
The drawdown can be determined by any of the following methods:

(1) $D - B$ = 31.5 ft - 26.9 ft = 4.6 ft (9.6 m - 8.2 m = 1.4 m)

(2) $A - C$ = 23.1 ft - 18.5 ft = 4.6 ft (7.0 m - 5.6 m = 1.4 m)

(3) $p_1 - p_2$ = 10 - 8 = 2 psi = 2 × 2.31 = 4.6 ft (0.68 - 0.55 = 0.13 bar = 0.13 - 10.3 = 1.4 m)

Figure A-4-3.5.3 Air line method of determining depth of water level.



A-4-4

Several methods of installing a vertical pump can be followed, depending upon the location of the well and facilities available. Since most of the unit is under ground, extreme care should be used in assembling and installing it and in thoroughly checking the work as it progresses. The following simple method is the most common.

(a) Construct a tripod or portable derrick and use two sets of installing clamps over the open well or pump house. After the derrick is in place, the alignment should be checked carefully with the well or wet pit to avoid any trouble when setting the pump.

(b) Attach the set of clamps to the suction pipe on which the strainer has already been placed and lower into the well until clamps rest on a block beside the well casing or on the pump foundation.

(c) Attach the clamps to the pump stage assembly, bring over the well, and install pump stages to the suction pipe, until each piece has been installed in accordance with the manufacturer's instructions.

A-4-6.1.1

The setting of the impellers should be undertaken only by a representative of the pump manufacturer. Improper setting will develop excessive friction loss by rubbing of impellers on pump seals with resultant increase in power demand. If the impellers are adjusted too high, there will be a loss in capacity, and full capacity is vital for fire pump service. The top shaft nut should be locked or pinned after proper setting.

A-4-6.1.2

Pumping units are checked at the factory for smoothness of performance and should operate satisfactorily on the job. If excessive vibration is present, the following conditions can be causing the trouble:

(1) Bent pump or column shaft

(2) Impellers not properly set within the pump bowls

(3) Pump not hanging freely in the well

(4) Strain transmitted through the discharge piping

Excessive motor temperature is generally caused either by a maintained low voltage of the electric service or by improper setting of impellers within the pump bowls.

A-5-1

All of the requirements in Chapter 2 might not apply to positive displacement pumps.

A-5-1.2

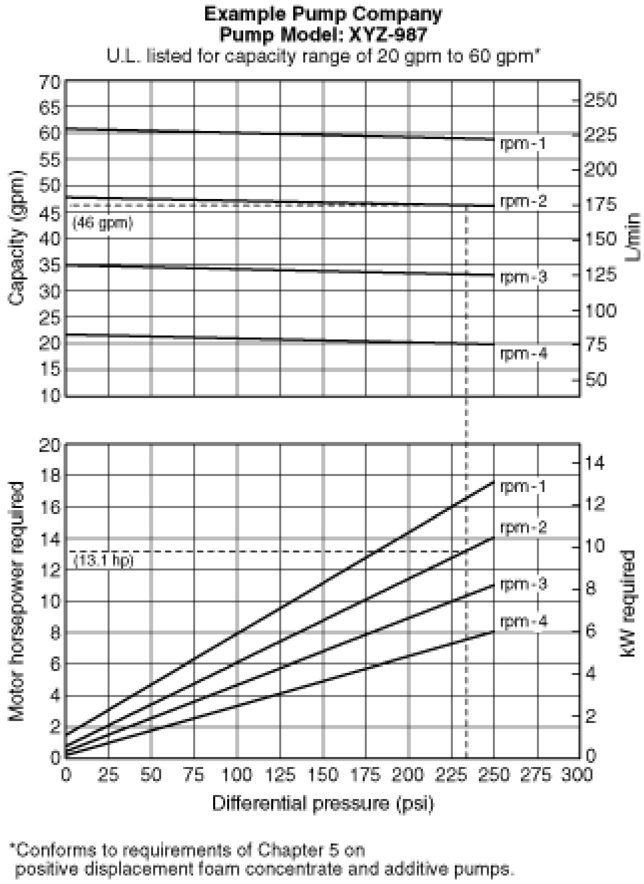
Special attention to the pump inlet piping size and length should be noted.

A-5-1.2.2

Sample pump characteristic curve and example of pump selection methods. Characteristic performance curves should be in accordance with HI 3.6, *Rotary Pump Tests*.

Example: An engineer is designing a foam-water fire protection system. It has been determined, after application of appropriate safety factors, that the system needs a foam concentrate pump capable of 45 gpm at the maximum system pressure of 230 psi. Using the performance curve *(see Figure A-5-1.2.2)* for pump model "XYZ-987," this pump is selected for the application. First, find 230 psi on the horizontal axis labeled "Differential Pressure" and then proceed vertically to the flow curve to 45 gpm. It is noted that this particular pump produces 46 gpm at a standard motor speed designated "RPM-2." This pump is an excellent fit for the application. Next, proceed to the power curve for the same speed of "RPM-2" at 230 psi and find that it requires 13.1 horsepower to drive the pump. An electric motor will be used for this application so a 15-horsepower motor at "RPM-2" is the first available motor rating above this minimum requirement.

Figure A-5-1.2.2 Positive displacement pump selection example.



A-5-1.5

Positive displacement pumps are tolerance dependent and corrosion can affect pump performance and function. *(See HI 3.5, Standard for Rotary Pumps for Nomenclature, Design, Application and Operation.)*

A-5-2.2

Specific flow rates should be determined by the applicable NFPA standard. Viscose concentrates and additives have significant pipe friction loss from the supply tank to the pump suction.

A-5-2.3

Generally, pump capacity is calculated by multiplying the maximum water flow by the percentage of concentration desired. To that product is then added 10 percent “over demand” to ensure adequate pump capacity is available under all conditions.

A-5-2.4

Generally, concentrate pump discharge pressure is required to be added to the maximum water pressure at the injection point plus 25 psi (2 bar).

A-5-3.1

It is not the intent of this standard to prohibit the use of stationary pumps for water mist systems.

A-5-4.2

Positive displacement pumps are capable of quickly exceeding their maximum design discharge pressure if operated against a closed discharge system. Other forms of protective devices (e.g., automatic shutdowns, rupture discs) are considered as a part of the pumping system and are generally beyond the scope of the pump manufacturer's supply. These components should be safely designed into and supplied by the system designer and/or by the user. *(See Figure A-5-4.2 for proposed schematic layout of pump requirements.)*

A-5-4.3

Only the return to source and external styles should be used when the outlet line can be closed for more than a few minutes. Operation of a pump with an integral relief valve and a closed outlet line will cause overheating of the pump and a foamy discharge of fluid after the outlet line is reopened.

Figure A-5-4.2 Typical foam pump piping and fittings.

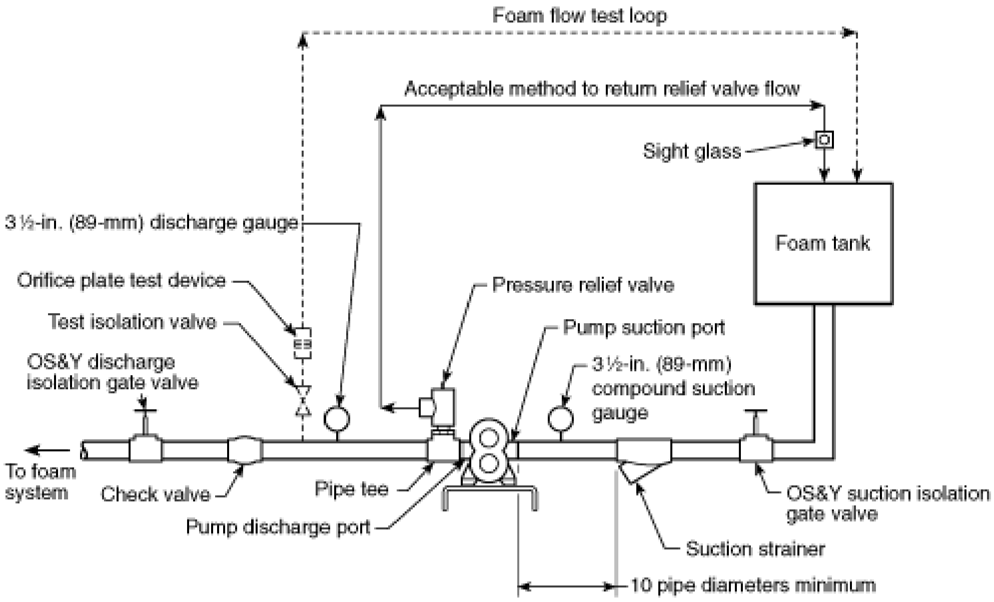


Figure A-5-4.4 Typical water mist system pump piping and fittings.

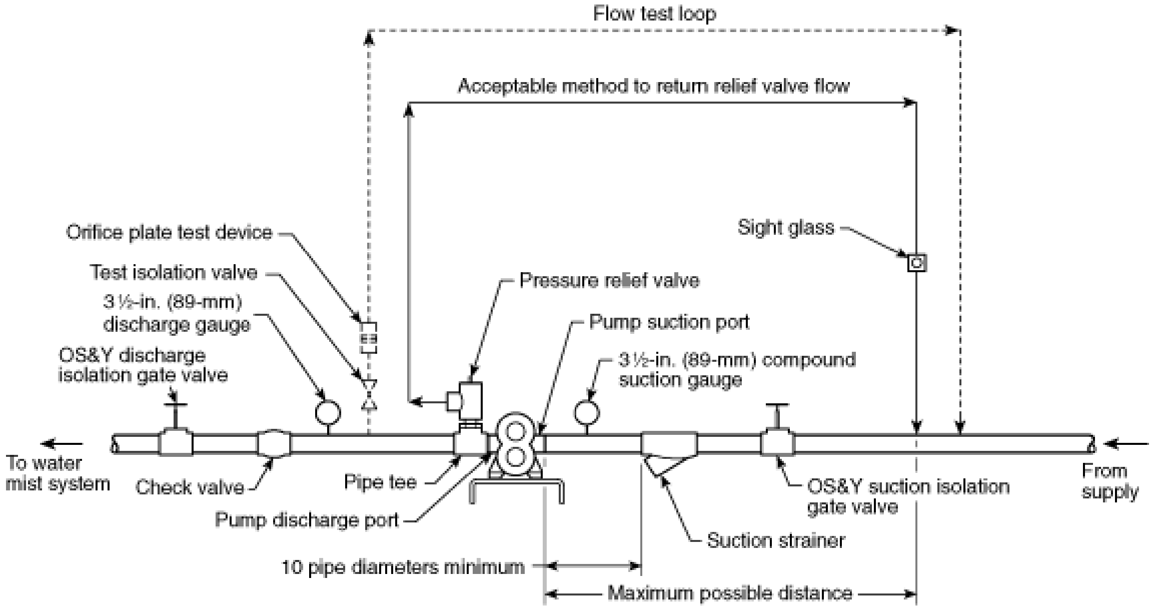


Figure A-5-4.5 Standard mesh sizes.

Mesh	20	40	60	80	100
Opening (in.)	0.034	0.015	0.0092	0.007	0.0055
Opening (µ)	860	380	230	190	140

A-5-4.4

Backpressure on the discharge side of the pressure relief valve should be considered. *(See Figure A-5-4.4 for proposed schematic layout of pump requirement.)*

A-5-4.5

Strainer recommended mesh size is based on the internal pump tolerances. *(See Figure A-5-4.5 for standard mesh sizes.)*

A-5-5.1

Positive displacement pumps are typically driven by electric motors, internal combustion engines, or water motors.

A-5-6

These controllers can incorporate means to permit automatic unloading or pressure relief when starting the pump driver.

A-6-2.2

An on-site electrical power production facility located on the premises served by the fire pump is considered an acceptable facility if it is in a separate power house or cut off from the main buildings. It can be used as one of the two sources of current supply. Where two sources are used with power transfer switches, see NFPA 70, *National Electrical Code*, Article 695.

A-6-2.3

A reliable source possesses the following characteristics:

(1) Infrequent power disruptions from environmental or man-made conditions

(2) A separate service connection or connection to the supply side of the service disconnect

(3) Service and feeder conductors either buried under 2 in. (50 mm) of concrete or encased in 2 in. (50 mm) of concrete or brick within a building

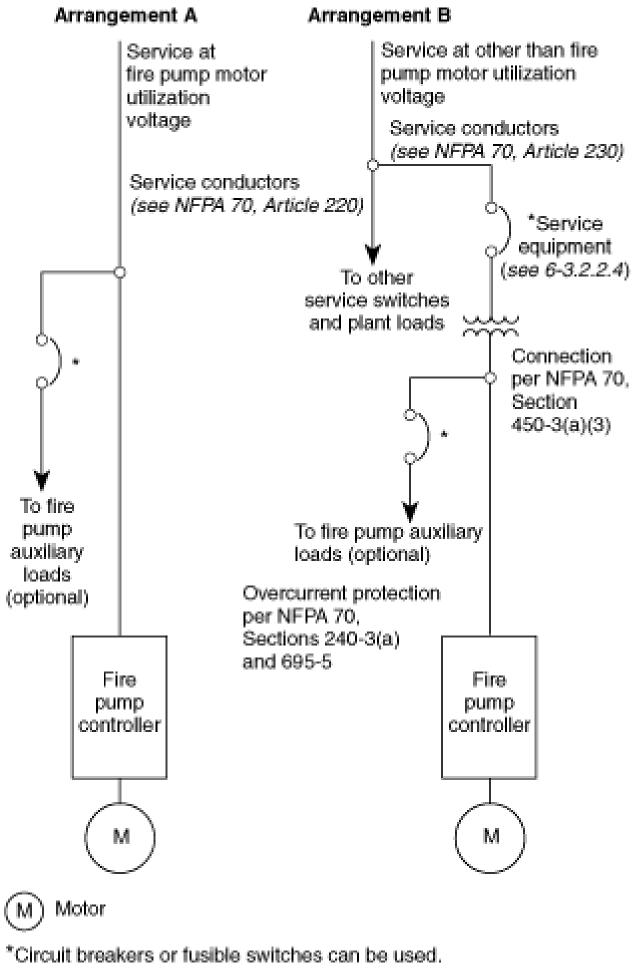
Typical methods of routing power from the source to the motor are shown in Figure A-6-2.3. Other configurations are also acceptable. The determination of the reliability of a service is left up to the discretion of the authority having jurisdiction.

A-6-3

Where risks involved are large and interruption of fire pump service would seriously affect protection, at least two separate circuits from the power plant(s) to the pump room should be provided. The circuits should be run by separate routes or in such a manner that failure of more than one at the same time would be only a remote possibility.

A completely underground circuit from the generating station to the pump room is strongly recommended and should be obtained where practicable. Where such construction is not available, an overhead circuit is allowed, but that part of the circuit adjacent to the plant served by the fire pump or to exposing plants should be run with special reference to damage in case of fire. Where the pump room is part of, or in close proximity to, the plant that the pump is designed to protect, the wires should be underground for some distance from the pump room.

Figure A-6-2.3 Typical power supply arrangements from source to motor.



A-6-3.1

Under premise fire conditions, service and feeder connections are susceptible to failure from collapsing structural and other members within the premise as well as failure from fire. Under fire conditions generated by overcurrent within these service and feeder conductors, the characteristics of 6-3.1 minimize the possibility of fire spread.

Typical methods of routing power from the source to the motor are shown in Figure A-6-2.3. Other configurations are also acceptable.

A-6-3.2.2.1

Where the alternate power is from an on-site generator, the alternate service equipment need not be located in the fire pump room.

The committee considered the potential arrangement of providing fire pump power from the secondary side of the transformer, which supplies other electrical loads of the facility. The committee recognizes that it is possible to supply the fire pump power ahead of other plant loads and to protect the fire pump power circuit by proper electrical coordination. However, the committee is concerned that, while responding to an emergency, fire fighters might seek to disconnect electrical power to the facility by opening the transformer primary disconnect, which in this case would isolate power to the fire pump as well. In addition, the committee is concerned that the designed electrical coordination can be compromised by ongoing additional electrical loads to the facility power distribution system. Therefore, if electrical service is supplied to the facility at voltage higher than utilization voltage, the committee feels that a separate transformer to provide power to the fire pump is appropriate.

A-6-4

Normally, conductor sizing is based on appropriate sections of NFPA 70, *National Electrical Code,* Article 430, except larger sizes could be required to meet the requirements of NFPA 70, Section 695-8(e) (NFPA 20, Section 6-4). Transformer sizing is to be in accordance with NFPA 70, Section 695-5(a), except larger minimum sizes could be required to meet the requirements of NFPA 70, Section 695-8(e) (NFPA 20, Section 6-4).

A-6-5.1.1.1

The locked rotor currents for 460-V motors are approximately six times the full-load current.

A-6-6.2

Where a generator is installed to supply power to loads in addition to one or more fire pump drivers, the fuel supply should be sized to provide adequate fuel for all connected loads for the desired duration. The connected loads can include such loads as emergency lighting, exit signage, and elevators.

A-7-1.2.2

The phrase *suitable for use* means that the controller and transfer switch have been prototype tested and have demonstrated by these tests their short-circuit withstandability and interrupting capacity at the stated magnitude of short-circuit current and voltage available at their line terminals *(see ANSI/UL 509, Standard for Safety Industrial Control Equipment, and ANSI/UL 1008, Standard for Safety Automatic Transfer Switches).*

A short-circuit study should be made to establish the available short-circuit current at the controller in accordance with IEEE 141, *Electric Power Distribution for Industrial Plants;* IEEE 241, *Electric Systems for Commercial Buildings;* or other acceptable methods.

After the controller and transfer switch have been subjected to a high fault current, they may not be suitable for further use without inspection or repair. *(See NEMA ICS 2.2, Maintenance of Motor Controllers After a Fault Condition.)*

A-7-2.1

If the controller must be located outside of the pump room, a glazed opening should be provided in the pump room wall for observation of the motor and pump during starting. The pressure control pipe line should be protected against freezing and mechanical injury.

A-7-3.3.1

For more information, see NEMA 250, *Enclosures for Electrical Equipment*.

A-7-3.6

For more information, see NFPA 70, *National Electrical Code*.

A-7-3.7.3

Pump operators should be familiar with instructions provided for controllers and should observe in detail all of their recommendations.

A-7-4.1

Operation of the surge arrester should not cause either the isolating switch or the circuit breaker to open. Arresters in ANSI/IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits*, are normally zinc-oxide without gaps.

A-7-4.2.1 Exception No. 1.

For more information, see NFPA 70, *National Electrical Code*.

A-7-4.2.3

For more information, see NFPA 70, *National Electrical Code*.

A-7-4.3.1

For more information, see NFPA 70, *National Electrical Code*, Article 100.

A-7-4.3.3

Attention should be given to the type of service grounding to establish circuit breaker interrupting rating based on grounding type employed.

A-7-4.3.3(4)

The interrupting rating can be less than the suitability rating where other devices within the controller assist in the current-interrupting process.

A-7-4.3.3(6) Exception.

Current limiters are melting link-type devices that, where used as an integral part of a circuit breaker, limit the current during a short circuit to within the interrupting capacity of the circuit breaker.

A-7-4.4(c)

It is recommended that the locked rotor overcurrent device not be reset more than two consecutive times if tripped due to a locked rotor condition without first inspecting the motor for excessive heating and to alleviate or eliminate the cause preventing the motor from attaining proper speed.

A-7-4.5.6 Exception.

The alarm should incorporate local visible indication and contacts for remote indication. The alarm can be incorporated as part of the power available indication and loss of phase alarm *[see 7-4.6.1 and 7-4.7(b)]*.

A-7-4.6

The pilot lamp for alarm and signal service should have operating voltage less than the rated voltage of the lamp to ensure long operating life. When necessary, a suitable resistor or potential transformer should be used to reduce the voltage for operating the lamp.

A-7-4.7

Where unusual conditions exist whereby pump operation is not certain, a “failed-to-operate” alarm is recommended. In order to supervise the supervised power source for the alarm circuit, the controller can be arranged to start upon failure of the supervised alarm circuit power.

A-7-5.1

The following definitions are derived from NFPA 70, *National Electrical Code.*

(a) *Automatic.* Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

(b) *Nonautomatic.* Action requiring intervention for its control. As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

A-7-5.2.1

Installation of the pressure-sensing line in 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. *[See Figures A-7-5.2.1(a) and (b).]*

A-7-5.2.1(e)

The pressure recorder should be able to record a pressure at least 150 percent of the pump discharge pressure under no-flow conditions. In a high-rise building this requirement can exceed 400 psi (27.6 bar). This pressure recorder should be readable without opening the fire pump controller enclosure. This requirement does not mandate a separate recording device for each controller. A single multichannel recording device can serve multiple sensors.

A-7-5.3.2

The emergency-run mechanical control provides means for externally, manually closing the motor contactor across-the-line to start and run the fire pump motor. It is intended for emergency use when normal electric/magnetic operation of the contactor is not possible.

When so used on controllers designed for reduced-voltage starting, the 15 percent voltage drop limitation in Section 6-4 is not applicable.

Figure A-7-5.2.1(a) Piping connection for each automatic pressure switch (for fire pump and jockey pumps).

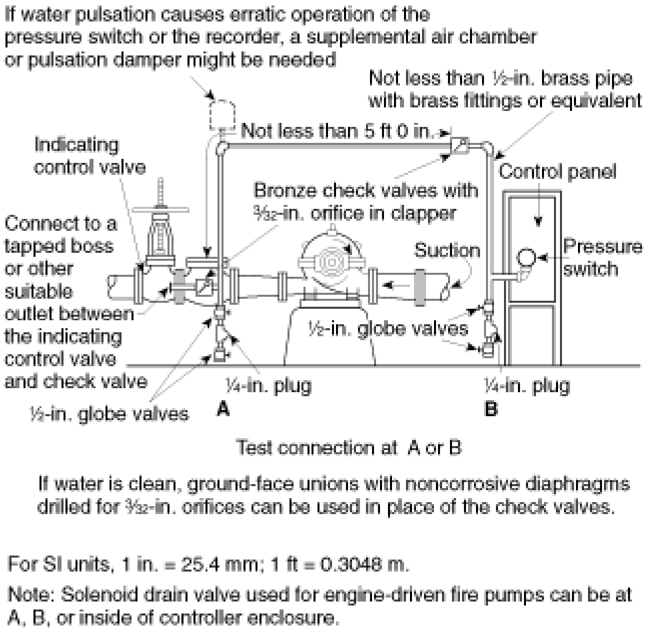
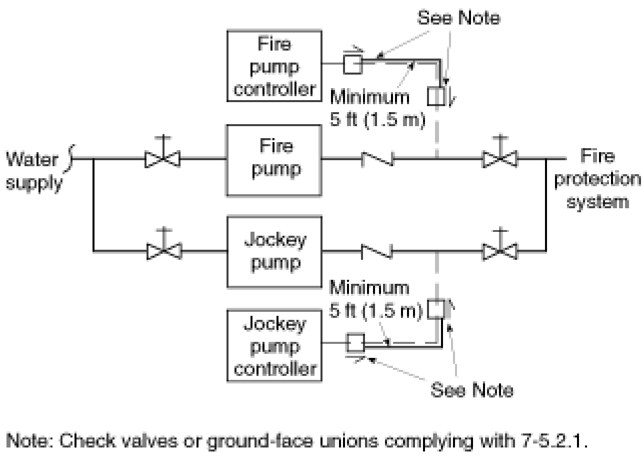


Figure A-7-5.2.1(b) Piping connection for pressure-sensing line.



A-7-7

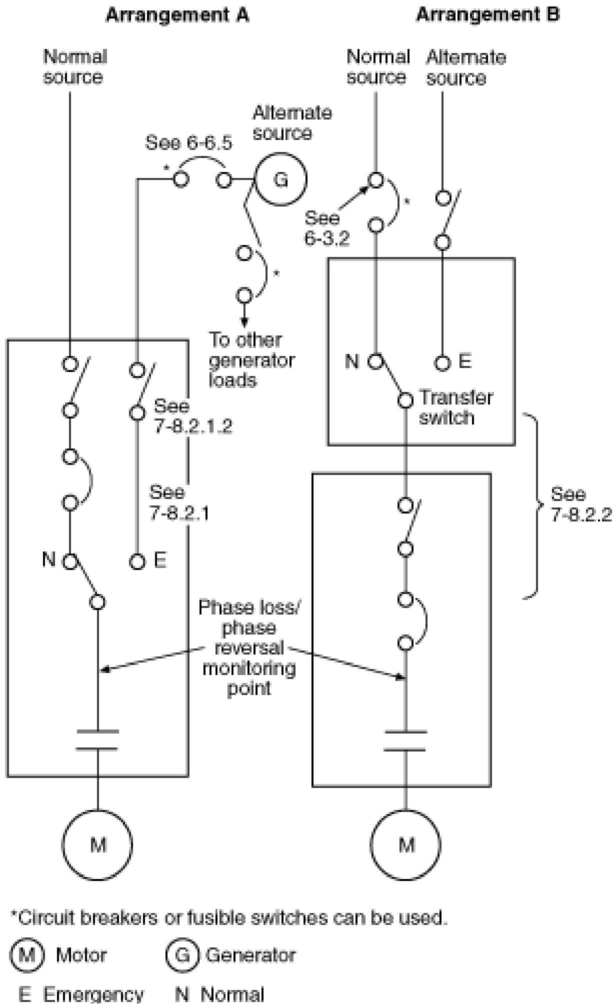
The authority having jurisdiction can permit the use of a limited-service controller for special situations where such use is acceptable to said authority.

A-7-8

Typical fire pump controller and transfer switch arrangements are as shown in Figure A-7-8.

Other configurations can also be acceptable.

Figure A-7-8 Typical fire pump controller and transfer switch arrangements.



A-7-8.2

The compartmentalization or separation is to prevent propagation of a fault in one compartment to the source in the other compartment.

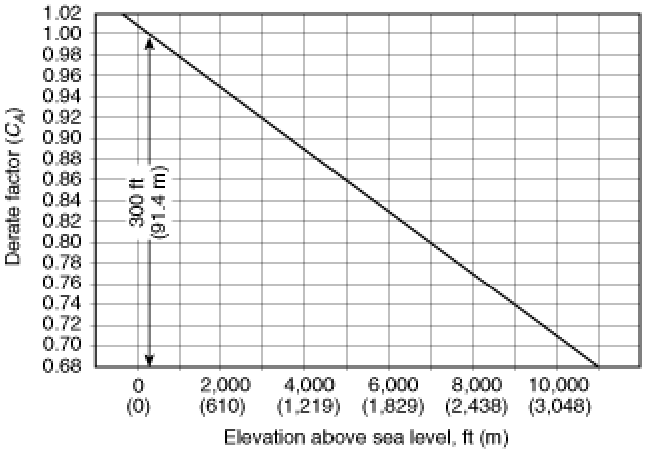
A-8-2.2.1

For more information, see SAE J-1349, *Engine Power Test Code — Spark Ignition and Compression Engine*.

A-8-2.2.4

See Figure A-8-2.2.4.

Figure A-8-2.2.4 Elevation derate curve.



Note: Correction equation:
Corrected engine horsepower = ($C_A + C_T - 1$) × Listed engine horsepower
C_A = Derate factor for elevation
C_T = Derate factor for temperature

A-8-2.2.5

Pump room temperature rise should be considered when determining the maximum ambient temperature specified. *(See Figure A-8-2.2.5.)*

A-8-2.4.7

A harness on the enclosure will ensure ready wiring in the field between the two sets of terminals.

A-8-2.4.8

Terminations should be made using insulated ring-type compression connectors for post-type terminal blocks. Saddle-type terminal blocks should have the wire stripped with about $^1/_{16}$ in. (1.6 mm) of bare wire showing after insertion in the saddle to ensure that no insulation is below the saddle. Wires should be tugged to ensure adequate tightness of the termination.

A-8-2.4.9

Manual mechanical operation of the main battery contactor will bypass all of the control circuit wiring within the controller.

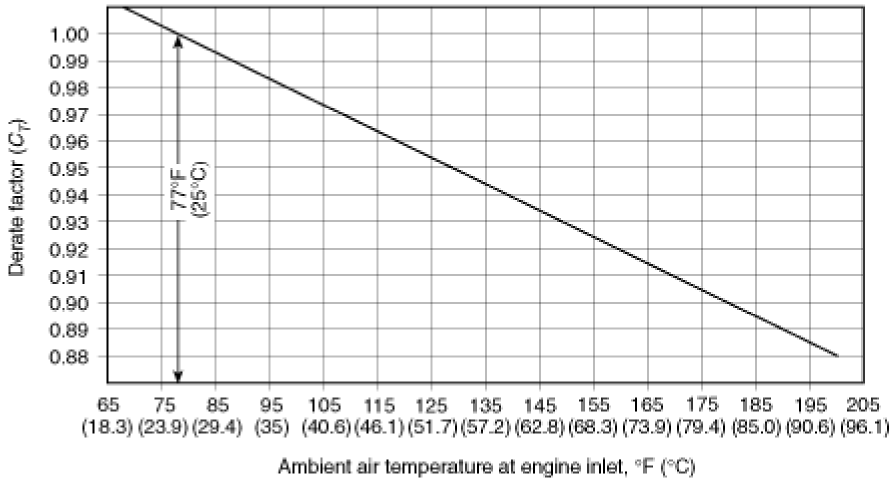
A-8-2.5.2.3

A single charger that automatically alternates from one battery to another can be used on two battery installations.

A-8-2.5.2.5

Location at the side of and level with the engine is recommended to minimize lead length from battery to starter.

Figure A-8-2.2.5 Temperature derate curve.



Note: Correction equation:
Corrected engine horsepower = $(C_A + C_T - 1)$ × Listed engine horsepower

C_A = Derate factor for elevation
C_T = Derate factor for temperature

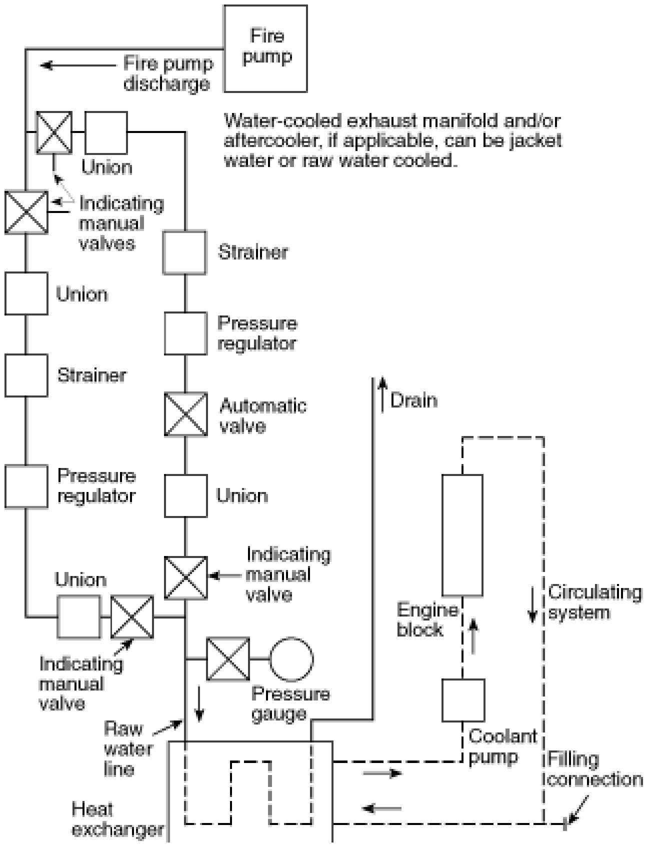
A-8-2.5.4.4

Automatic maintenance of air pressure is preferable.

A-8-2.6.3

See Figure A-8-2.6.3.

Figure A-8-2.6.3 Cooling water line with bypass.



A-8-2.6.4

Where the water supply can be expected to contain foreign materials such as wood chips, leaves, lint, and so forth, the strainers required in 8-2.6.3 should be of the duplex filter type. Each filter (clean) element should be of sufficient filtering capacity to permit full water flow for a 3-hour period. In addition, a duplex filter of the same size should be installed in the bypass line. *(See Figure A-8-2.6.3.)*

A-8-3

The engine-driven pump can be located in a pump house or in a pump room that should be entirely cut off from the main structure by noncombustible construction.

A-8-3.2

For optimum room ventilation, the air supply ventilator and air discharge should be located on opposite walls.

When calculating the maximum temperature of the pump room, the radiated heat from the engine, the radiated heat from the exhaust piping, and all other heat-contributing sources should be considered.

If the pump room is to be ventilated by a power ventilator, reliability of the power source during a fire should be considered. If the power source is unreliable, the temperature rise calculation should assume the ventilator is not operable.

Air consumed by the engine for combustion should be considered as part of the air changes in the room.

Pump rooms with heat exchanger-cooled engines will typically require more air changes than engine air consumption will provide. To control the temperature rise of the room, additional air flow through the room is normally required. *[See Figure A-8-3.2(a).]*

Pump rooms with radiator-cooled engines could have sufficient air changes due to the radiator discharge and engine consumption. *[See Figure A-8-3.2(b).]*

Figure A-8-3.2(a) Typical ventilation system for a heat exchanger-cooled diesel-driven pump.

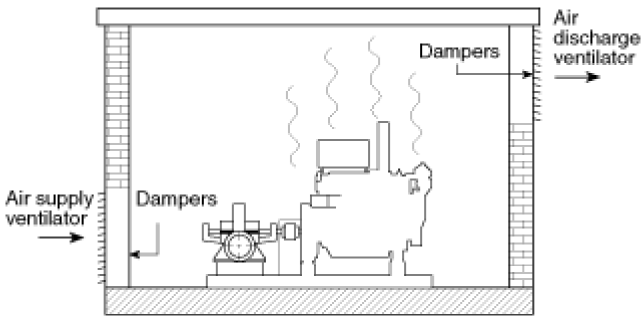
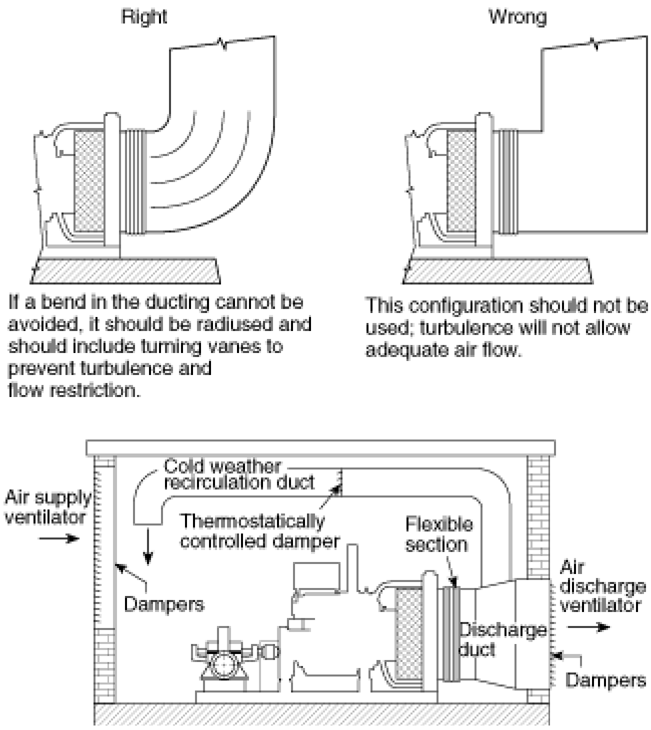


Figure A-8-3.2(b) Typical ventilation system for a radiator-cooled diesel-driven pump.



A-8-3.2.1

When motor-operated dampers are used in the air supply path, they should be spring operated to the open position and motored closed. Motor-operated dampers should be signaled to open when or before the engine begins cranking to start.

The maximum air flow restriction limit for the air supply ventilator is necessary to be compatible with listed engines to ensure adequate air flow for cooling and combustion. This restriction will typically include louvers, bird screen, dampers, duct, or anything in the air supply path between the pump room and the outdoors.

Motor-operated dampers are recommended for the heat exchanger-cooled engines to enhance convection circulation.

Gravity-operated dampers are recommended for use with radiator-cooled engines to simplify their coordination with the air flow of the fan.

A-8-3.2.2

When motor-operated dampers are used in the air discharge path, they should be spring operated to the open position, motored closed, and be signaled to open when or before the engine begins cranking to start.

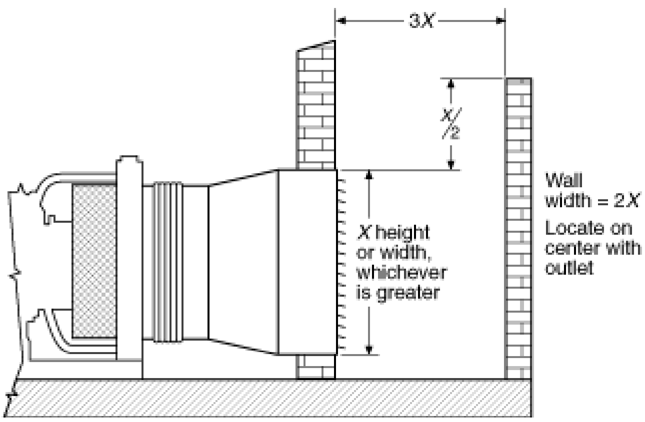
Prevailing winds can work against the air discharge ventilator. Therefore, the winds should be considered when determining the location for the air discharge ventilator. *(See Figure A-8-3.2.2 for the recommended wind wall design.)*

For heat exchanger-cooled engines, an air discharge ventilator with motor-driven dampers designed for convection circulation is preferred in lieu of a power ventilator. This arrangement will require the size of the ventilator to be larger, but it is not dependent on a power source that might not be available during the pump operation.

For radiator-cooled engines, gravity-operated dampers are recommended. Louvers and motor-operated dampers are not recommended due to the restriction to air flow they create and the air pressure they must operate against.

The maximum air flow restriction limit for the air discharge ventilator is necessary to be compatible with listed engines to ensure adequate air flow cooling.

Figure A-8-3.2.2 Typical wind wall.



A-8-4.3

One gallon per horsepower (5.07 L/kW) is equivalent to 1 pint per horsepower (0.473 L/kW) per hour for 8 hours. Where prompt replenishment of fuel supply is unlikely, a reserve supply should be provided along with facilities for transfer to the main tanks.

A-8-4.5

Diesel fuel storage tanks should be located preferably inside the pump room or pump house, if permitted by local regulations. Fill and vent lines in such case should be extended to outdoors. The fill pipe can be used for a gauging well where practical.

A-8-4.6

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, can be used as a guide for diesel fuel piping. Figure A-8-4.6 shows a suggested diesel engine fuel system.

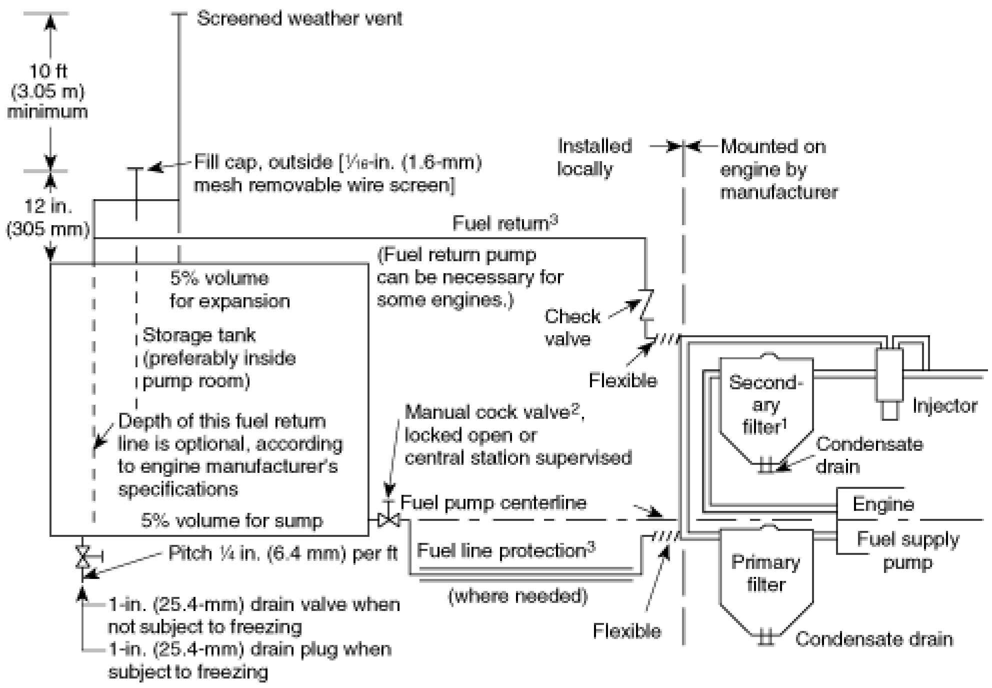
A-8-4.7

The pour point and cloud point should be at least 10°F (5.6°C) below the lowest expected fuel temperature *(see 2-7.2 and 8-4.5).*

A-8-5.3

A conservative guideline is that, if the exhaust system exceeds 15 ft (4.5 m) in length, the pipe size should be increased one pipe size larger than the engine exhaust outlet size for each 5 ft (1.5 m) in added length.

Figure A-8-4.6 Fuel system for diesel engine-driven fire pump.



¹Secondary filter behind or before engine fuel pump, according to engine manufacturer's specifications.
²Excess fuel can be returned to fuel supply pump suction, if recommended by engine manufacturer.
³Size of fuel piping, according to engine manufacturer's specifications.

A-8-6

Internal combustion engines necessarily embody moving parts of such design and in such number that the engines cannot give reliable service unless given intelligent care. The manufacturer's instruction book covering care and operation should be readily available, and pump operators should be familiar with its contents. All of its provisions should be observed in detail.

A-8-6.2

See NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* for proper maintenance of engine(s), batteries, fuel supply, and environmental conditions.

A-8-6.5

Proper engine temperature when the engine is not running can be maintained through the circulation of hot water through the jacket or through heating of engine water by electric elements inserted into the block. As a general rule, water heaters and oil heaters are required for diesel engines below 70°F (21°C). The benefits to be gained are as follows:

(1) Quick starting (fire pump engines may have to carry full load as soon as started)

(2) Reduced engine wear

(3) Reduced drain on batteries

(4) Reduced oil dilution

(5) Reduced carbon deposits, so that the engine is far more likely to start every time

A-9-2.1

If the controller must be located outside of the pump room, a glazed opening should be provided in the pump room wall for observation of the motor and pump during starting. The pressure-control pipeline should be protected against freezing and mechanical injury.

A-9-3.1

In areas affected by excessive moisture, heat can be useful in reducing the dampness.

A-9-3.3.1

For more information, see NEMA 250, *Enclosures for Electrical Equipment*.

A-9-3.8

Pump operators should be familiar with instructions provided for controllers and should observe in detail all of their recommendations.

A-9-4.1.2

It is recommended that the pilot lamp for alarm and signal service have operating voltage less than the rated voltage of the lamp to ensure long operating life. When necessary, a suitable resistor should be used to reduce the voltage for operating the lamp.

A-9-4.2(3)

The following trouble signals should be monitored remotely from the controller.

(1) A common signal can be used for the following trouble indications: items in 9-4.1.3(a) through (e) and loss of output of battery charger on the load side of the dc overcurrent protective device.

(2) If there is no other way to supervise loss of power, the controller can be equipped with a power failure circuit, which should be time delayed to start the engine upon loss of current output of the battery charger.

A-9-4.4

The pressure recorder should be able to record a pressure at least 150 percent of the pump discharge pressure under no-flow conditions. In a high-rise building this requirement can exceed 400 psi (27.6 bar). This requirement does not mandate a separate recording device for each controller. A single multichannel recording device can serve multiple sensors.

A-9-5

The following definitions are derived from NFPA 70, *National Electrical Code.*

(a) *Automatic.* Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

(b) *Nonautomatic.* The implied action requires personal intervention for its control. As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

A-9-5.5.2

Manual shutdown of fire pumps is preferred. Automatic fire pump shutdown can occur during an actual fire condition when relatively low-flow conditions signal the controller that pressure requirements have been satisfied.

A-9-6.9

The pressure recorder should be able to record a pressure at least 150 percent of the pump discharge pressure under no-flow conditions. In a high-rise building this requirement can exceed 400 psi (27.6 bar). This requirement does not mandate a separate recording device for each controller. A single multichannel recording device can serve multiple sensors.

A-10-1.3

Single-stage turbines of maximum reliability and simplicity are recommended where the available steam supply will permit.

A-10-2.1.1

The casing can be of cast iron.

Some applications can require a turbine-driven fire pump to start automatically but not require the turbine to be on pressure control after starting. In such cases a satisfactory quick-opening manual-reset valve installed in a bypass of the steam feeder line around a manual control valve can be used.

Where the application requires the pump unit to start automatically and after starting continue to operate by means of a pressure signal, the use of a satisfactory pilot-type pressure control valve is recommended. This valve should be located in the bypass around the manual control valve in the steam feeder line. The turbine governor control valve, when set at approximately 5 percent above the normal full-load speed of the pump under automatic control, would act as a preemergency control.

In the arrangements set forth in the two preceding paragraphs, the automatic valve should be located in the bypass around the manual control valve, which would normally be kept in the closed position. In the event of failure of the automatic valve, this manual valve could be opened, allowing the turbine to come to speed and be controlled by the turbine governor control valve(s).

The use of a direct-acting pressure regulator operating on the control valve(s) of a steam turbine is not recommended.

A-10-3

The following information should be taken into consideration when planning a steam supply, exhaust, and boiler feed for a steam turbine-driven fire pump.

(a) The steam supply for the fire pump should preferably be an independent line from the boilers. It should be run so as not to be liable to injury in case of fire in any part of the property. The other steam lines from the boilers should be controlled by valves located in the boiler room. In an emergency, steam can be promptly shut off from these lines, leaving the steam supply entirely available for the fire pump. Strainers in steam lines to turbines are recommended.

(b) The steam throttle at the pump should close against the steam pressure. It should preferably be of the globe pattern with a solid disc. If, however, the valve used has a removable composition ring, the disc should be of bronze and the ring made of sufficiently hard and durable material, and so held in place in the disc as to satisfactorily meet severe service conditions. Gate valves are undesirable for this service because they cannot readily be made leaktight, as is possible with the globe type of valve. The steam piping should be so arranged and trapped that the pipes can be kept free of condensed steam.

(c) In general, a pressure-reducing valve should not be placed in the steam pipe supplying the fire pump. There is no difficulty in designing turbines for modern high-pressure steam, and this gives the simplest and most dependable unit. A pressure-reducing valve introduces a possible obstruction in the steam line in case it becomes deranged. In most cases the turbines can be protected by making the safety valve required by 10-2.1.2 of such size that the pressure in the casing will not exceed 25 psi (1.7 bar). This valve should be piped outside of the pump room and, if possible, to some point where the discharge could be seen by the pump attendant. Where a pressure-reducing valve is used, the following points should be carefully considered.

(1) *Pressure-Reducing Valve.*

a. The pressure-reducing valve should not contain a stuffing box or a piston working in a cylinder.

b. The pressure-reducing valve should be provided with a bypass containing a globe valve to be opened in case of an emergency. The bypass and stop valves should be one pipe size smaller than the reducing valve, and they should be located so as to be readily accessible. This bypass should be arranged to prevent the accumulation of condensate above the reducing valve.

c. The pressure-reducing valve should be smaller than the steam pipe required by the specifications for the turbine.

(2) *Exhaust Pipe.* The exhaust pipe should run directly to the atmosphere and should not contain valves of any type. It should not be connected with any condenser, heater, or other system of exhaust piping.

(3) *Emergency Boiler Feed.* A convenient method of ensuring a supply of steam for the fire pump unit, in case the usual boiler feed fails, is to provide an emergency connection from the discharge of the fire pump. This connection should have a controlling valve at the fire pump and also, if desired, an additional valve located in the boiler room. A check valve also should be located in this connection, preferably in the boiler room. This emergency connection should be about 2 in. (51 mm) in diameter.

This method should not be used when there is any danger of contaminating a potable water supply. In situations where the fire pump is handling salt or brackish water, it may also be undesirable to make this emergency boiler-feed connection. In such situations, an effort should be made to secure some other secondary boiler-feed supply that will always be available.

A-11-2.2

In addition, representatives of the installing contractor and owner should be present.

A-11-2.6

The fire pump operation is as follows.

(a) *Motor-Driven Pump.* To start a motor driven pump, the following steps should be taken in the order given below.

(1) See that pump is completely primed.

(2) Close isolating switch and then close circuit breaker.

(3) Automatic controller will start pump if system demand is not satisfied (e.g., pressure

low, deluge tripped, etc.).

(4) For manual operation, activate switch or pushbutton, or manual start handle.

Circuit breaker-tripping mechanism should be set so that it will not operate when current in circuit is excessively large.

(b) *Steam-Driven Pump.* A steam turbine driving a fire pump should always be kept warmed up to permit instant operation at full rated speed. The automatic starting of the turbine should not be dependent on any manual valve operation or period of low-speed operation. If the pop safety valve on the casing blows, steam should be shut off and the exhaust piping examined for a possible closed valve or an obstructed portion of piping. Steam turbines are provided with governors to maintain speed at a predetermined point, with some adjustment for higher or lower speeds. Desired speeds below this range can be obtained by throttling the main throttle valve.

(c) *Diesel Engine-Driven Pump.* To start a diesel engine-driven pump, the operator should be familiar beforehand with the operation of this type of equipment. The instruction books issued by the engine and control manufacturer should be studied to this end.

The storage batteries should always be maintained in good order to ensure prompt satisfactory operation of this equipment (i.e., check electrolyte level and specific gravity, inspect cable conditions, corrosion, etc.).

(d) *Fire Pump Settings.* The fire pump system, when started by pressure drop, should be arranged as follows.

(1) The jockey pump stop point should equal the pump churn pressure plus the minimum static supply pressure.

(2) The jockey pump start point should be at least 10 psi (0.68-bar) less than the jockey pump stop point.

(3) The fire pump start point should be 5 psi (0.34 bar) less than the jockey pump start point. Use 10-psi (0.68-bar) increments for each additional pump.

(4) Where minimum run times are provided, the pump will continue to operate after attaining these pressures. The final pressures should not exceed the pressure rating of the system.

(5) Where the operating differential of pressure switches does not permit these settings, the settings should be as close as equipment will permit. The settings should be established by pressures observed on test gauges.

(6) *Example:*

Pump: 1000-gpm, 100-psi pump with churn pressure of 115 psi.

Suction Supply: 50 psi from city — minimum static. 60 psi from city — maximum static.

Jockey pump stop = 115 + 50 = 165 psi.

Jockey pump start = 165 - 10 = 155 psi.

Fire pump stop = 115 + 50 = 165 psi.

Fire pump start = 155 - 5 = 150 psi.

Fire pump maximum churn = 115 + 60 = 175 psi.

(For SI units, 1 psi = 0.0689 bar.)

(7) Where minimum run timers are provided, the pumps will continue to operate at churn pressure beyond the stop setting. The final pressures should not exceed the pressure rating of the system components.

(e) *Automatic Recorder.* The performance of all fire pumps should be automatically indicated on a pressure recorder to provide a record of pump operation and assistance in fire loss investigation.

A-11-2.6.1

The test equipment should be furnished by either the authority having jurisdiction or the installing contractor or the pump manufacturer, depending upon the prevailing arrangements made between the aforementioned parties. The equipment should include, but not necessarily be limited to, the following.

(a) *Use with Test Valve Header.* Fifty-foot (15-m) lengths, $2^1/_2$-in. (63.5-mm) lined hose, and Underwriters Laboratories' play pipe nozzles as needed to flow required volume of water.

Exception: Where test meter is provided, these may not be needed.

(b) *Instrumentation.* The following test instruments should be of high quality, accurate, and in good repair:

(1) Clamp on volt/ammeter

(2) Test gauges

(3) Tachometer

(4) Pitot tube with gauge (for use with hose and nozzle)

(c) *Instrumentation Calibration.* All test instrumentation should be calibrated by an approved testing and calibration facility within the 12 months prior to the test. Calibration documentation should be available for review by the authority having jurisdiction.

A majority of the test equipment used for acceptance and annual testing has never been calibrated. This equipment can have errors of 15 to 30 percent in readings. The use of uncalibrated test equipment can lead to inaccurately reported test results.

A-11-2.6.2.1

Where a hose valve header is used, it should be located where a limited [approximately 100 ft (30 m)] amount of hose is used to discharge water safely.

Where a flow test meter is used in a closed loop according to manufacturers' instructions, additional outlets such as hydrants, hose valves, and so forth, should be available to determine accuracy of metering device.

A-11-2.6.3

The test procedure is as follows.

(a) Make a visual check of the unit. If hose and nozzles are used, see that they are securely tied down. See that the hose valves are closed. If a test meter is used, the valve on the discharge side of the meter should be closed.

(b) Start the pump.

(c) Partially open one or two hose valves, or slightly open the meter discharge valve.

(d) Check the general operation of the unit. Watch for vibration, leaks (oil or water), unusual noises, and general operation. Adjust packing glands.

(e) Discharge of water. The steps are as follows.

(1) Where test valve header is used, regulate the discharge by means of the hose valves and a selection of the nozzle tips. It will be noticed that the play pipe has a removable tip. This tip has a $1^1/_8$-in. (28.6-mm) nozzle, and when the tip is removed, the play pipe has a $1^3/_4$-in. (44.4-mm) nozzle. Hose valves should be shut off before removing or putting on the $1^1/_8$-in. (28.6-mm) tip.

(2) Where test meter is used, regulate the discharge valve to achieve various flow readings.

(3) Important test points are at 150 percent rated capacity, rated capacity, and shutoff. Intermediate points can be taken if desired to help develop the performance curve.

(f) Record the following data at each test point *[see Figure A-11-2.6.3(f)]*.

(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 test meter, record gpm (L/min).

(5) Amperes.

(6) Volts.

(g) Calculation of test results is as follows.

(1) *Rated Speed.* Determine that pump is operating at rated rpm.

(2) *Capacity.* For hose valve header, using a fire stream table, determine the gpm (L/min) for each nozzle at each Pitot reading. For example, 16 psi (1.1 bar) Pitot pressure with $1^3/_4$-in. (44.4-mm) nozzle indicates 364 gpm (1378 L/min). Add the gpm for each hose line to determine total volume. For test meter, the total gpm (L/min) is read directly.

(3) *Total Head*. For horizontal pumps total head is the sum of the following.

a. Pressure measured by the discharge gauge at pump discharge flange.

b. Velocity head difference, pump discharge, and pump suction.

c. Gauge elevation corrections to pump centerline (plus or minus).

d. Pressure measured by suction gauge at pump suction flange. This value is negative when pressure is above zero.

For vertical pumps total head is the sum of the following.

a. Pressure measured by the discharge gauge at pump discharge flange

b. Velocity head at the discharge

c. Distance to the supply water level

d. Discharge gauge elevation correction to centerline of discharge

(4) *Electrical Input.* Voltage and amperes are read directly from the volt/ammeter. This reading 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, the maximum amperes is approximately 1.15 times motor amperes, because changes in power factor and efficiency are not considered. If the maximum amperes 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 should the maximum amperes logged on the test exceed the calculated maximum amperes. This measurement is important since a poor power supply with low voltage will cause a high ampere reading. This condition 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, the capacity, head, and power should be corrected from the test values at test speed to the rated speed of the pump. The corrections are made as follows:

Capacity:

$$Q_2 = \frac{N_2}{N_1} \times Q_1$$

Where

Q_1=capacity at test speed in gpm (L/min)

Q_2 = capacity at rated speed in gpm (L/min)

N_1= test speed in rpm

N_2 = rated speed in rpm

Head:

$$H_2 = \left[\frac{N_2}{N_1}\right]^2 \times H_1$$

Where

H_1 = head at test speed in ft (m)

H_2 = head at rated speed in ft (m)

Horsepower:

$$hp_2 = \left[\frac{N_2}{N_1}\right]^3 \times hp_1$$

Where

hp_1 =horsepower (kW) at test speed

hp_2 = horsepower (kW) at rated speed

(6) *Conclusion*. The final step in the test calculation is generally a plot of test points. A 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.

A-11-2.6.5

A simulated test of the phase reversal device is an acceptable test method.

A-11-2.7.1

All controller starts required for tests described in 11-2.6, 11-2.7, 11-2.8, and 11-2.10 should accrue respectively to this number of tests.

Figure A-11-2.6.3(f) Pump acceptance test data. *(Courtesy of Factory Mutual Research Corp.)*

PUMP ACCEPTANCE TEST DATA **Refer to P & P F(A) – 512.12 & DS 3 – 7N**

PROPERTY OF		INDEX NO.	DIST. OFFICE
ADDRESS		TESTED BY	DATE
CITY	STATE	PLACO	CODE
SUBJECT	CONFERRED WITH		

PUMP

SHAFT ☐ HORIZONTAL ☐ VERTICAL	MANUFACTURER	APPROVED ☐ YES ☐ NO	SHOP OR SERIAL NO.		MODEL OR T'
RATED GPM	RATED HEAD-FT. (psi)	RATED RPM	SUCTION FROM	TANK SIZE	TANK HEIGHT

IF VERTICAL TYPE

VERTICAL DIST. DISCH. GAUGE TO WATER LEVEL	STATIC FT	RIGHT-ANGLE GEAR DRIVE	MANUFACTURER	SHOP OR SERIAL NO.	APPROVED ☐ YES ☐ NO
	PUMPING FT		MODEL OR TYPE	PERFORMANCE ☐ SMOOTH ☐ ROUGH	

DRIVER

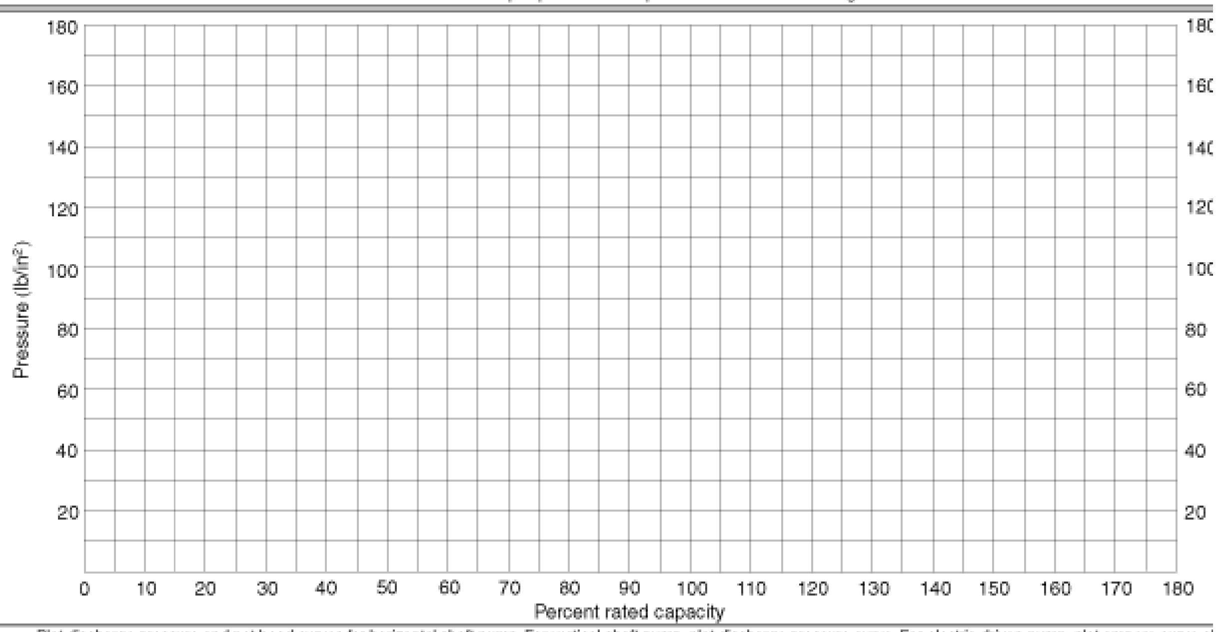
MANUFACTURER	APPROVED ☐ YES ☐ NO	SHOP OR SERIAL NO.	MODEL OR TYPE	RATED H.P.	RATED RPM		
☐ ELECTRIC MOTOR	RATED VOLT.	OPERATING VOLT.	RATED F.L. AMPS	AMPS AT 150%	PHASE	CYCLES	SERVICE FACT(
☐ DIESEL ENGINE	☐ GASOLINE ENGINE	☐ GAS ENGINE	☐ STEAM TURBINE	☐ PRESS. GOVERNOR BUILT IN	☐ INDEPENDENT	☐ TURBINE STEAM PR	

CONTROLLER

MANUFACTURER	APPROVED ☐ YES ☐ NO	START _____ psi ☐ MANUAL ☐ PRESS DROP ☐ AUTO ☐ WATER FLOW	STOP _____ psi ☐ MANUAL ☐ AUTO	JOCKEY PUMP ☐ YES ON ____ ☐ NO OFF ____
SHOP OR SERIAL NO.	MODEL OR TYPE			

SPEED RPM	DISCHARGE PRESSURE PSI	SUCTION PRESSURE PSI	NET HEAD PSI	STREAMS			GALLONS PER MINUTE	PERCENT OF RATED CAPACITY	VOLTS	AMPS	STEAM PRES	
				NO.	SIZE	PITOT PRESSURE					THROTTLE	(

Readings marked (+) in suction column are heads above atmosphere, those marked (–) are lifts.
For vertical shaft pumps omit suction pressure and net head readings.



Plot discharge pressure and net head curves for horizontal shaft pump. For vertical shaft pump, plot discharge pressure curve. For electric-driven pump, plot ampere curve al

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Appendix B Possible Causes of Pump Troubles

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Causes of Pump Troubles.

This appendix contains a partial guide for locating pump troubles and their possible causes *(see Figure B-1)*. It also contains a partial list of suggested remedies. *(For other information on this subject, see Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.)*

The causes listed here are in addition to possible mechanical breakage that would be obvious on visual inspection. In case of trouble it is suggested that those troubles that can be checked easily should be corrected first or eliminated as possibilities.

B-1.1 Air Drawn into Suction Connection Through Leak(s).

Air drawn into suction line through leaks causes a pump to lose suction or fail to maintain its discharge pressure. Uncover suction pipe and locate and repair leak(s).

B-1.2 Suction Connection Obstructed.

Examine suction intake, screen, and suction pipe and remove obstruction. Repair or provide screens to prevent recurrence. *(See 2-9.8.)*

B-1.3 Air Pocket in Suction Pipe.

Air pockets cause a reduction in delivery and pressure similar to an obstructed pipe. Uncover suction pipe and rearrange to eliminate pocket. *(See 2-9.6.)*

B-1.4 Well Collapsed or Serious Misalignment.

Consult a reliable well drilling company and the pump manufacturer regarding recommended repairs.

Figure B-1 Possible causes of fire pump troubles.

Fire pump troubles	Suction				Pump										
	Air drawn into suction connection through leak(s)	Suction connection obstructed	Air pocket in suction pipe	Well collapsed or serious misalignment	Stuffing box too tight or packing improperly installed, worn, defective, too tight, or incorrect type	Water seal or pipe to seal obstructed	Air leak into pump through stuffing boxes	Impeller obstructed	Wearing rings worn	Impeller damaged	Wrong diameter impeller	Actual net head lower than rated	Casing gasket defective permitting internal leakage (single-stage and multistage pumps)	Pressure gauge is on top of pump casing	Incorrect impeller adjustment (vertical shaft turbine-type pump only)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Excessive leakage at stuffing box					✗										
Pump or driver overheats				✗	✗	✗		✗			✗				✗
Pump unit will not start				✗	✗										✗
No water discharge	✗	✗	✗					✗							
Pump is noisy or vibrates				✗	✗			✗		✗					
Too much power required				✗	✗			✗	✗		✗		✗		✗
Discharge pressure not constant for same gpm	✗				✗	✗	✗								
Pump loses suction after starting	✗	✗	✗			✗	✗								
Insufficient water discharge	✗	✗	✗			✗	✗	✗	✗	✗	✗	✗	✗		✗
Discharge pressure too low for gpm discharge	✗	✗	✗		✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	

Fire pump troubles	Pump (cont.)					Driver and/or Pump					Driver				
	Impellers locked	Pump is frozen	Pump shaft or shaft sleeve scored, bent, or worn	Pump not primed	Seal ring improperly located in stuffing box, preventing water from entering space to form seal	Excess bearing friction due to lack of lubrication, wear, dirt, rusting, failure, or improper installation	Rotating element binds against stationary element	Pump and driver misaligned	Foundation not rigid	Engine-cooling system obstructed	Faulty driver	Lack of lubrication	Speed too low	Wrong direction of rotation	Speed too high
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Excessive leakage at stuffing box			✗					✗							
Pump or driver overheats			✗	✗	✗	✗	✗	✗	✗	✗		✗		✗	✗
Pump unit will not start	✗	✗				✗					✗	✗			
No water discharge				✗											
Pump is noisy or vibrates			✗			✗	✗	✗	✗			✗			
Too much power required			✗			✗	✗	✗	✗			✗		✗	✗
Discharge pressure not constant for same gpm															
Pump loses suction after starting					✗										
Insufficient water discharge													✗	✗	
Discharge pressure too low for gpm discharge													✗	✗	

B-1.5 Stuffing Box Too Tight or Packing Improperly Installed, Worn, Defective, Too Tight, or of Incorrect Type.

Loosen gland swing bolts and remove stuffing box gland halves. Replace packing.

B-1.6 Water Seal or Pipe to Seal Obstructed.

Loosen gland swing bolt and remove stuffing box gland halves along with the water seal ring and packing. Clean the water passage to and in the water seal ring. Replace water seal ring, packing gland, and packing in accordance with manufacturer’s instructions.

B-1.7 Air Leak into Pump Through Stuffing Boxes.

Same as possible cause B-1.6.

B-1.8 Impeller Obstructed.

Does not show on any one instrument, but pressures fall off rapidly when an attempt is made to draw a large amount of water.

For horizontal split-case pumps, remove upper case of pump and remove obstruction from impeller. Repair or provide screens on suction intake to prevent recurrence.

For vertical shaft turbine-type pumps, lift out column pipe *(see Figures A-4-2.2.1 and A-4-2.2.2)* and pump bowls from wet pit or well and disassemble pump bowl to remove obstruction from impeller.

For close-coupled, vertical in-line pumps, lift motor on top pull-out design and remove obstruction from impeller.

B-1.9 Wearing Rings Worn.

Remove upper case and insert feeler gauge between case wearing ring and impeller wearing ring. Clearance when new is 0.0075 in. (0.19 mm). Clearances of more than 0.015 in. (0.38 mm) are excessive.

B-1.10 Impeller Damaged.

Make minor repairs or return to manufacturer for replacement. If defect is not too serious, order new impeller and use damaged one until replacement arrives.

B-1.11 Wrong Diameter Impeller.

Replace with impeller of proper diameter.

B-1.12 Actual Net Head Lower than Rated.

Check impeller diameter and number and pump model number to make sure correct head curve is being used.

B-1.13 Casing Gasket Defective Permitting Internal Leakage (Single-Stage and Multistage Pumps).

Replace defective gasket. Check manufacturer's drawing to see whether gasket is required.

B-1.14 Pressure Gauge Is on Top of Pump Casing.

Place gauges in correct location. *(See Figure A-3-3.1.)*

B-1.15 Incorrect Impeller Adjustment (Vertical Shaft Turbine-Type Pump Only).

Adjust impellers according to manufacturer's instructions.

B-1.16 Impellers Locked.

For vertical shaft turbine-type pumps, raise and lower impellers by the top shaft adjusting nut. If this adjustment is not successful, follow the manufacturer's instructions.

For horizontal split-case pumps, remove upper case and locate and eliminate obstruction.

B-1.17 Pump Is Frozen.

Provide heat in the pump room. Disassemble pump and remove ice as necessary. Examine parts carefully for damage.

B-1.18 Pump Shaft or Shaft Sleeve Scored, Bent, or Worn.

Replace shaft or shaft sleeve.

B-1.19 Pump Not Primed.

If a pump is operated without water in its casing, the wearing rings are likely to seize. The first warning is a change in pitch of the sound of the driver. Shut down the pump.

For vertical shaft turbine-type pumps, check water level to determine whether pump bowls have proper submergence.

B-1.20 Seal Ring Improperly Located in Stuffing Box, Preventing Water from Entering Space to Form Seal.

Loosen gland swing bolt and remove stuffing box gland halves along with the water-seal ring and packing. Replace, putting seal ring in proper location.

B-1.21 Excess Bearing Friction Due to Lack of Lubrication, Wear, Dirt, Rusting, Failure, or Improper Installation.

Remove bearings and clean, lubricate, or replace as necessary.

B-1.22 Rotating Element Binds Against Stationary Element.

Check clearances and lubrication and replace or repair the defective part.

B-1.23 Pump and Driver Misaligned.

Shaft running off center because of worn bearings or misalignment. Align pump and driver according to manufacturer's instructions. Replace bearings according to manufacturer's instructions. *(See Section 3-5.)*

B-1.24 Foundation Not Rigid.

Tighten foundation bolts or replace foundation if necessary. *(See Section 3-4.)*

B-1.25 Engine-Cooling System Obstructed.

Heat exchanger or cooling water systems too small. Cooling pump faulty. Remove thermostats. Open bypass around regulator valve and strainer. Check regulator valve operation. Check strainer. Clean and repair if necessary. Disconnect sections of cooling system to locate and remove possible obstruction. Adjust engine-cooling water-circulating pump belt to obtain proper speed without binding. Lubricate bearings of this pump.

If overheating still occurs at loads up to 150 percent of rated capacity, contact pump or engine manufacturer so that necessary steps can be taken to eliminate overheating.

B-1.26 Faulty Driver.

Check electric motor, internal combustion engine, or steam turbine, in accordance with manufacturer's instructions, to locate reason for failure to start.

B-1.27 Lack of Lubrication.

If parts have seized, replace damaged parts and provide proper lubrication. If not, stop pump and provide proper lubrication.

B-1.28 Speed Too Low.

For electric motor drive, check that rated motor speed corresponds to rated speed of pump, voltage is correct, and starting equipment is operating properly.

Low frequency and low voltage in the electric power supply prevent a motor from running at rated speed. Low voltage can be due to excessive loads and inadequate feeder capacity or (with private generating plants) low generator voltage. The generator voltage of private generating plants can be corrected by changing the field excitation. When low voltage is from the other causes mentioned, it can be necessary to change transformer taps or increase feeder capacity.

Low frequency usually occurs with a private generating plant and should be corrected at the source. Low speed can result in older type squirrel-cage-type motors if fastenings of copper bars to end rings become loose. The remedy is to weld or braze these joints.

For steam turbine drive, check that valves in steam supply pipe are wide open; boiler steam pressure is adequate; steam pressure is adequate at the turbine; strainer in the steam supply pipe is not plugged; steam supply pipe is of adequate size; condensate is removed from steam supply pipe, trap, and turbine; turbine nozzles are not plugged; and setting of speed and emergency governor is correct.

For internal combustion engine drive, check that setting of speed governor is correct; hand throttle is opened wide; and there are no mechanical defects such as sticking valves, timing off, or spark plugs fouled, and so forth. The latter can require the services of a trained mechanic.

B-1.29 Wrong Direction of Rotation.

Instances of an impeller turning backward are rare but are clearly recognizable by the extreme deficiency of pump delivery. Wrong direction of rotation can be determined by comparing the direction in which the flexible coupling is turning with the directional arrow on the pump casing.

With polyphase electric motor drive, two wires must be reversed; with dc driver, the armature connections must be reversed with respect to the field connections. Where two sources of electrical current are available, the direction of rotation produced by each should be checked.

B-1.30 Speed too High.

See that pump- and driver-rated speed correspond. Replace electric motor with one of correct rated speed. Set governors of variable-speed drivers for correct speed. Frequency at private generating stations can be too high.

B-1.31 Rated Motor Voltage Different from Line Voltage.

For example, a 220- or 440-V motor on 208- or 416-V line. Obtain motor of correct rated voltage or larger size motor. *(See Section 6-4.)*

B-1.32 Faulty Electric Circuit, Obstructed Fuel System, Obstructed Steam Pipe, or Dead Battery.

Check for break in wiring open switch, open circuit breaker, or dead battery. If circuit breaker in controller trips for no apparent reason, make sure oil is in dash pots in accordance with manufacturer's specifications. Make sure fuel pipe is clear, strainers are clean, and control valves open in fuel system to internal combustion engine. Make sure all valves are open and strainer is clean in steam line to turbine.

B-2 Warning.

Chapters 6 and 7 include electrical requirements that discourage the installation of disconnect means in the power supply to electric motor-driven fire pumps. This requirement is intended to ensure the availability of power to the fire pumps. When equipment connected to those circuits is serviced or maintained, the employee can have unusual exposure to electrical and other hazards. It can be necessary to require special safe work practices and special safeguards, personal protective clothing, or both.

B-3 Maintenance of Fire Pump Controllers After a Fault Condition.

B-3.1 Introduction.

In a fire pump motor circuit that has been properly installed, coordinated, and in service prior to the fault, tripping of the circuit breaker or the isolating switch indicates a fault condition in excess of operating overload.

It is recommended that the following general procedures be observed by qualified personnel in the inspection and repair of the controller involved in the fault. These procedures are not intended to cover other elements of the circuit, such as wiring and motor, which can also require attention.

B-3.2 Caution.

All inspections and tests are to be made on controllers that are de-energized at the line terminal, disconnected, locked out, and tagged so that accidental contact cannot be made with live parts and so that all plant safety procedures will be observed.

B-3.2.1 Enclosure.

Where substantial damage to the enclosure, such as deformation, displacement of parts, or burning has occurred, replace the entire controller.

B-3.2.2 Circuit Breaker and Isolating Switch.

Examine the enclosure interior, circuit breaker, and isolating switch for evidence of possible damage. If evidence of damage is not apparent, the circuit breaker and isolating switch can continue to be used after closing the door.

If there is any indication that the circuit breaker has opened several short-circuit faults, or if signs of possible deterioration appear within either the enclosure, circuit breaker, or isolating switch (e.g., deposits on surface, surface discoloration, insulation cracking, or unusual toggle operation), replace the components. Verify that the external operating handle is capable of opening and closing the circuit breaker and isolating switch. If the handle fails to operate the device, this would also indicate the need for adjustment or replacement.

B-3.2.3 Terminals and Internal Conductors.

Where there are indications of arcing damage, overheating, or both, such as discoloration and melting of insulation, replace the damaged parts.

B-3.2.4 Contactor.

Replace contacts showing heat damage, displacement of metal, or loss of adequate wear allowance of the contacts. Replace the contact springs where applicable. If deterioration extends beyond the contacts, such as binding in the guides or evidence of insulation damage, replace the damaged parts or the entire contactor.

B-3.2.5 Return to Service.

Before returning the controller to service, check for the tightness of electrical connections and for the absence of short circuits, ground faults, and leakage current.

Close and secure the enclosure before the controller circuit breaker and isolating switch are energized. Follow operating procedures on the controller to bring it into standby condition.

Appendix C Referenced Publications

C-1

The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 12. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

C-1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1999 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1996 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 1996 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 1999 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 1995 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 1998 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment*, 1997 edition.

NFPA 70, *National Electrical Code®*, 1999 edition.

C-1.2 Other Publications.

C-1.2.1 ANSI Publication.

American National Standards Institute, Inc., 11 West 42nd Street, New York, NY 10036.

ANSI/IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits*, 1987.

C-1.2.2 ANSI/UL Publications.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 509, *Standard for Safety Industrial Control Equipment*, 1989.

ANSI/UL 1008, *Standard for Safety Automatic Transfer Switches*, 1989.

C-1.2.3 AWWA Publication.

American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

AWWA C104, *Cement-Mortar Lining for Cast-Iron and Ductile-Iron Pipe and Fittings for Water*, 1990.

C-1.2.4 HI Publications.

Hydraulics Institute, 1230 Keith Building, Cleveland, OH 44115.

Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps, 14th ed., 1983.

HI 3.5, *Standard for Rotary Pumps for Nomenclature, Design, Application and Operation*, 1994.

HI 3.6, *Rotary Pump Tests*, 1994.

C-1.2.5 IEEE Publications.

Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE 141, *Electric Power Distribution for Industrial Plants*, 1986.

IEEE 241, *Electric Systems for Commercial Buildings*, 1990.

C-1.2.6 NEMA Publications.

National Electrical Manufacturers Association, 1300 N. 17th Street, Suite 1847, Rosslyn, VA 22209.

NEMA Industrial Control and Systems Standards, ICS 2.2, *Maintenance of Motor Controllers After a Fault Condition*, 1983.

NEMA 250, *Enclosures for Electrical Equipment*, 1991.

NEMA MG 1, *Motors and Generators*, 1993.

C-1.2.7 SAE Publication.

Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J-1349, *Engine Power Test Code — Spark Ignition and Compression Engine*, 1990.

Formal Interpretation

Formal Interpretation
NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 2-3
F.I. 80-8

Question: Can a fire pump be used at 150 percent of its rated capacity if it delivers the required water quantity at the required pressure to the fire protection system?

Answer: Yes, providing it is acceptable to the authority having jurisdiction.

Issue Edition: 1980
Reference: 2-3.1
Date: July 1982

NATIONAL FIRE PROTECTION ASSOCIATION

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 2-9.3, 4-1.1
F.I. 83-11

Question 1: Paragraph 2-9.4 — A vertical turbine pump built into a "can" can be an alternative arrangement for a typical horizontal split case pump. When such is the case in a fire protection system, will the vertical pump so arranged be required to operate at the 150 percent rated capacity point with NPSH available at the pump suction flange of 19 ft (corresponding to a 15 ft suction lift)?

Answer: Yes.Further, the complete assembly, including the can, shall be tested as a unit.

Question 2: Paragraph 4-1.1 — Was a vertical turbine-type pump built into a "can" for boosting city water pressure to a higher discharge pressure in a typical high rise building considered in all details as this paragraph was written?

Answer: No.Even though "booster" application is not specifically mentioned, there is no conflict.

Issue Edition: 1983
Reference: 2-9.4, 4-1.1, and 5-2.1
Date: March 1984

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 2-10.4, A-2-10.4
F.I. 83-6A

Question 1: Is a "slow opening" type of pressure regulating valve, pilot- or electrically operated, acceptable in fire pump discharge line(s) to help prevent water hammer when pump(s) start(s) up? Pressure maintained in piping system supplied by pump could be kept lower than pump "no flow" discharge pressure.

Answer: No. A normally closed valve in the discharge line represents an unacceptable potential failure possibility.

Question 2: If answer to Question 1 is “no,” would it be acceptable to install two such valves in parallel, providing redundancy in case of failure of one valve to open?

Answer: No. A redundant valve still holds the potential for failure.

Issue Edition: 1983
Reference: 2-10.4, A-2-10.4
Date: March 1984

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 2-19
F.I. 83-14

Question: Can a domestic water pump in a dual-purpose water supply system function as the pressure maintenance pump as related to Section 2-19?

Answer: Yes.

Issue Edition: 1983
Reference: 2-19
Date: March 1985

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 3-5.1, 8-2.3.1
F.I. 83-6

Question 1: Is a common automatic universal joint considered as a flexible connection between fire pumps and fire pump drivers?

Answer: Yes, when installed between a horizontal driver and a right angle gear drive installed on separate bases.

Question 2: Can a single automatic universal be considered as a flexible connection between a fire pump and fire pump driver?

Answer: No, automatic universals must be used in pairs with a slip joint to minimize transfer of horizontal thrust. (See 3-5.1 and 4-5.1.3.1.)

Issue Edition: 1983
Reference: 3-4.1 and 8-2.3.1
Date: October 1983

Formal Interpretation
NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 7-4.3, 7-4.4
F.I. 83-1

Question 1: Is it the intent to allow continuous 300 percent of full load current electrical overloading of the fire pump feeder circuits, including transformers, disconnects or other devices on this circuit?

Answer:

a) Relative to protective devices in the fire pump feeder circuit, such devices shall not open under locked rotor currents (see 6-3.2.2).

b) Relative to the isolating means and the circuit breaker of the fire pump controller, it is the intent of 7-4.3 to permit 300 percent of full load motor current to flow continuously through these devices until an electrical failure occurs. [This statement also applies to the motor starter of the fire pump controller, but this device is not in the feeder (see Section 1-7).]

c) Relative to all devices other than those cited above, refer to NFPA 70 for sizing.

Question 2: If the answer to Question 1 is no, what is meant by “setting the circuit breaker at 300 percent of full load current”?

Answer: The phrase “setting the circuit breaker at 300 percent of full load current” means that the circuit breaker will not open (as a normal operation) at 300 percent of full load current. It does not mean that the circuit breaker can pass 300 percent of full load current without ultimately failing from overheating.

Question 3: What is meant by "calibrated up to and set at 300 percent" of motor full load current?

Answer: Question 2 answers the "set at 300 percent" of motor full load current. "Calibrated up to 300 percent" of motor full load current means that calibration at approximately 300 percent is provided by the manufacturer of the circuit breaker.

Issue Edition: 1983
Reference: 6-3.5, 7-4.3
Date: January 1983

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 7-4.7(b)
F.I. No.: 20-99-1

Question No: Relative to paragraph 7-4.7 (b), is the intent of the Committee that the fire pump controller detect loss of any phase whether the pump motor is running or not?

Answer: Yes

Issue Edition: 1999
Reference: 7-4.7(b)
Issue Date: May 23, 2000
Effective Date: June 12, 2000

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: Chapter 8
F.I. 83-10

Question 1: Is it the intent of NFPA 20 to require the diesel engine fire pump to reach rated speed without delay in a fire condition?

Answer: Yes.

Question 2: If "yes" to the above question, will an automatic soft start unit which will throttle engine from an idle to start to full RPM within an adjustable period of time (0-1 minute) be permitted?

Answer: No. Delaying the fire protection system response to a fire by up to one minute could result in the fire getting out of control. Response to a fire by the sprinkler system should be as quick as possible.

Question 3: Is it the intent of NFPA 20 to permit automatic safety switches to stop the engine when:

a. Water temperature exceeds a present safe working limit?

b. Water in tank is at a level lower than present safe working limit?

c. Lubricating oil pressure is lower than a present working limit?

Answer: No. NFPA 20 requires an overspeed shutdown device, but the systems monitoring water temperature, oil pressure, etc., are warning devices not shutdown. Continuing to run the engine with excessive water temperature or low oil pressure may result in damage to an engine such that an overhaul is required. However, it will continue to operate (and pump water) for some time depending upon the severity of the temperature increase or pressure loss. In the event of a fire, the fire pump engine is considered to be expendable if necessary in order to continue fighting the fire.

Issue Edition: 1983
Reference: Chapter 8
Date: March 1984

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 8-2.5.4.2
F.I.

Question: Is it the intent of 8-2.5.4.2 that the automatic electric solenoid valve be:

(a) battery operated and not operated by the building electrical service,

(b) be normally energized so that the valve will open upon being de-energized?

Answer: (a) Yes.

Answer: (b) No.

Issue Edition: 1974
Reference: 8-2.7.2
Date: February 1975

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 9-4.1.3
F.I. 87-3

Question 1: Does 9-4.1.3, Item (e) mean that an alarm and a visible indicator are required at the moment the engine attempts to crank and a battery is incapable of cranking the engine?

Answer: Yes.

Question 2: Does 9-4.1.3, Item (e) mean that an alarm and a visible indicator are required at the moment a battery is missing or has a nonconductive circuit?

Answer: Yes.

Issue Edition: 1987
Reference: 9-4.2.3
Date: November 1988

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 9-4.1.3, 9-5.3.1

F.I. 87-2

Question 1: Is a separate visible indicator and a common audible alarm capable of being heard while the engine is running, and provided to indicate trouble caused by failure of engine to start automatically, required to be operable with the main switch in the “manual” position.

Answer: No.

Question 2: Does a controller arranged to manually start the engine by opening the solenoid drain valve when the main switch is placed in the “test” position satisfy the requirement of 9-5.3.1 that the controller shall be arranged to manually start the engine by opening the solenoid valve drain when so initiated by the operator.

Answer: Yes.

Issue Edition: 1987
Reference: 9-4.2.3, 9-5.3.1
Date: June 1988

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: 11-2.6.4
F.I. 80-3

Question 1: Does “rated speed” mean the installed motor nameplate speed? (Assuming nameplate voltage and frequency.)

Answer: No. “Rated speed” means the speed for which the pump was listed.

Question 2: Does “rated speed” mean manufacturer's performance speed as shown on certified test curve?

Answer: Yes, if this is the speed for which the pump was listed.

Question 3: Does “rated speed” mean actual installed motor speed at maximum load of the motor-pump combination with nameplate voltage and frequency?

Answer: No. “Rated speed” means the speed for which the pump was listed.

Issue Edition: 1980
Reference: 11-2.6.4

Date: August 1981

Formal Interpretation

NFPA 20

Stationary Pumps for Fire Protection

1999 Edition

Reference: A-8-3
F.I. 83-4

Question 1: Is it the intent of A-8-3 that the engine driven pump be located in a pump room separated from *motor driven fire pumps*?

Answer: No.

Question 2: Is it the intent of A-8-3 that the engine driven pump be located in a pump room separated from *pumps associated with other plant systems*?

Question 3: Is it the intent of A-8-3 that the engine driven pump be located in a pump room separated from *plant facilities other than pumping facilities*?

Answer (2 & 3): No. The location of the engine or electric driven pump in relation to pumps and other equipment associated with plant systems should be determined by the authority having jurisdiction.

Issue Edition: 1983
Reference: A-8-3
Date: April 1983

Formal Interpretation

NFPA 20

Standard for the Installation of Stationary Pumps for Fire Protection

1999 Edition

Reference: 2-21.2
F.I. No.: 20-99-2

Question: Does the "maximum anticipated flow" mean periodic "spitting" from an RPZ that may occur under normal operating conditions?

Answer: No

Issue Edition: 1999
Reference: 2-21.2
Issue Date: August 29, 2001
Effective Date: September 18, 2001

Formal Interpretation

NFPA 20

Standard for the Installation of Stationary Pumps for Fire Protection

1999 Edition

Reference: 6-5.2.1, 1-1, 7-5.1.2
F.I. No.: 20-99-3

Question No. 1: Is this exception intended to exclude wound rotor motors from complying with the requirement in 6-5.2.1 which states "The motor capacity in horsepower shall be such that the maximum motor current in any phase under any condition of pump load and voltage unbalance shall not exceed the motor-rated full-load current multiplied by the service factor"?

Answer: No

Question No. 2: Are installations which require wound rotor motors and manual controllers for listed fire pump service excluded from NFPA 20?

Answer: No

Question No. 3: If a component in the fire protection system is not available as a listed component, does the supply of this non-listed component preclude the requirement for the installation to meet the requirements of NFPA 20?

Answer: No

Issue Edition: 1999
Reference: 6-5.1.2, 7-5.1.2
Issue Date: August 29, 2001
Effective Date: September 18, 2001

Formal Interpretation

NFPA 20

Standard for the Installation of Stationary Pumps for Fire Protection

1999 Edition

Reference: 6-2.3
F.I. No.: 20-99-4

Question No. 1: Do the requirements of Chapter 6, Section 6-2.3 apply to all Stationary Pumps for Fire Protection governed by NFPA 20 including positive displacement fire pumps?

Answer: Yes

Question No. 2: If the answer to question 1 is yes: Is it the intent to apply to positive displacement foam concentrate pumps?

Answer: Yes

Issue Edition: 1999
Reference: 6-2.3
Issue Date: February 5, 2002
Effective Date: February 25, 2002

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