

NFPA® 20

Standard for the Installation of Stationary Pumps for Fire Protection

2010 Edition



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NFPA® 20

Standard for the

Installation of Stationary Pumps for Fire Protection

2010 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 NFPA at its June Association Technical Meeting held June 8-11, 2009, in Chicago, IL. It was issued by the Standards Council on August 6, 2009, with an effective date of August 26, 2009, and supersedes all previous editions.

This edition of NFPA 20 was approved as an American National Standard on August 26, 2009.

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. Modern committee membership has included representatives of Underwriters Laboratories of both the United States and Canada, Insurance Services Office, Factory Mutual, Industrial Risk Insurers, national trade associations, state governments, 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, 1910–1913, 1915, 1918–1921, 1923–1929, 1931–1933, 1937, 1939, 1943, 1944, 1946–1948, 1951, 1953, 1955, 1957, 1959–1972, 1974, 1976, 1978, 1980, 1983, 1987, 1990, 1993, 1996, 1999, 2003, and 2007.

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 to make the system as reliable as possible.

The 1996 edition continued the changes initiated in the 1993 edition, and 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 included requirements for positive displacement pumps for both water mist and foam systems. The document title was revised to reflect this change, since the 1999 edition addressed requirements for pumps other than centrifugal. Enforceable language was added, particularly regarding protection of equipment.

Revisions for the 2003 edition included updating the document to conform with the latest edition of the *Manual of Style for NFPA Technical Committee Documents*. Provisions were also added to address the use of fire pump drivers using variable speed pressure limiting control. Acceptance test criteria were added to the document for replacement of critical path components of a fire pump installation.

For the 2007 edition, requirements for variable speed drives were refined, requirements for break tanks were added, and component replacement testing tables were included.

The 2010 edition now includes a new chapter on fire pumps for high-rise buildings. Requirements for pumps arranged in series were also added to the general requirements chapter. Chapter 11 of the standard has been reorganized.



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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.

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NFPA 20

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Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex C. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1* Scope.

1.1.1 This standard deals with the selection and installation of pumps supplying liquid for private fire protection.

1.1.2 The scope of this document shall include liquid supplies; suction, discharge, and auxiliary equipment; power supplies, including power supply arrangements; electric drive and control; diesel engine drive and control; steam turbine drive and control; and acceptance tests and operation.

1.1.3 This standard does not cover system liquid supply capacity and pressure requirements, nor does it cover requirements for periodic inspection, testing, and maintenance of fire pump systems.

1.1.4 This standard does not cover the requirements for installation wiring of fire pump units.

1.2 Purpose. 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.

1.3 Application.

1.3.1 This standard shall apply to centrifugal single-stage and multistage pumps of the horizontal or vertical shaft design and positive displacement pumps of the horizontal or vertical shaft design.

1.3.2 Requirements are established for the design and installation of single-stage and multistage pumps, pump drivers, and associated equipment.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units.

1.6.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

1.6.2 *Liter* and *bar* in this standard are outside of but recognized by SI.

1.6.3 Units are listed in Table 1.6.3 with conversion factors.

1.6.4 Conversion. The conversion procedure is to multiply the quantity by the conversion factor and then round the result to an appropriate number of significant digits.

1.6.5 Trade Sizes. Where industry utilizes nominal dimensions to represent materials, products, or performance, direct conversions have not been utilized and appropriate trade sizes have been included.



Table 1.6.3 System of Units

Name of Unit	Unit Abbreviation	Conversion Factor
Meter(s)	m	1 ft = 0.3048 m
Foot (feet)	ft	1 m = 3.281 ft
Millimeter(s)	mm	1 in. = 25.4 mm
Inch(es)	in.	1 mm = 0.03937 in.
Liter(s)	L	1 gal = 3.785 L
Gallon(s) (U.S.)	gal	1 L = 0.2642 gal
Cubic decimeter(s)	dm ³	1 gal = 3.785 dm ³
Cubic meter(s)	m ³	1 ft ³ = 0.0283 m ³
Cubic foot (feet)	ft ³	1 m ³ = 35.31 ft ³
Pascal(s)	Pa	1 psi = 6894.757 Pa; 1 bar = 10 ⁵ Pa
Pound(s) per square inch	psi	1 Pa = 0.000145 psi; 1 bar = 14.5 psi
Bar	bar	1 Pa = 10 ⁻⁵ bar; 1 psi = 0.0689 bar

Note: For additional conversions and information, see IEEE/ASTM SI10, *Standard for Use of the International System of Units (SI): The Modern Metric System*.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2008 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2010 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2008 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2006 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2009 edition.

NFPA 70®, *National Electrical Code*®, 2008 edition.

NFPA 101®, *Life Safety Code*®, 2009 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2010 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2009 edition.

2.3 Other Publications.

2.3.1 AGMA Publications. American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314-2730.

AGMA 390.03, *Handbook for Helical and Master Gears*, 1995.

2.3.2 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus*, 2000.

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 Alternating Current Power Circuits (>1 kV)*, 2005.

ANSI/IEEE C62.41, *IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits*, 1991.

2.3.3 HI Publications. Hydraulic Institute, 6 Campus Drive, First Floor North, Parsippany, NJ 07054-4406..

Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps, 14th edition, 1983.

HI 3.6, *Rotary Pump Tests*, 1994.

2.3.4 IEEE Publications. Institute of Electrical and Electronics Engineers, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE/ASTM SI10, *Standard for Use of the International System of Units (SI): The Modern Metric System*, 2003.

2.3.5 NEMA Publications. National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847, Rosslyn, VA 22209.

NEMA MG-1, *Motors and Generators*, 1998.

2.3.6 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 142, *Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids*, 2006.

ANSI/UL 508, *Standard for Industrial Control Equipment*, 2005.

2.3.7 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2007 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2006 edition.

NFPA 70®, *National Electrical Code*®, 2008 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2010 edition.

NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*, 2007 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2009 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3* 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.

3.2.4 Shall. Indicates a mandatory requirement.

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

3.2.6 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 or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 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.

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

3.3.3 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.

3.3.4 Automatic Transfer Switch. See 3.3.48.2.1.

3.3.5 Branch Circuit. See 3.3.7.1.

3.3.6 Break Tank. A tank providing suction to a fire pump whose capacity is less than the fire protection demand (flow rate times flow duration).

3.3.7 Circuit.

3.3.7.1 Branch Circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s). [70: Art. 100]

3.3.7.2 Fault Tolerant External Control Circuit. Those control circuits either entering or leaving the fire pump controller enclosure, which if broken, disconnected, or shorted will not prevent the controller from starting the fire pump from all other internal or external means and can cause the controller to start the pump under these conditions.

3.3.8 Circulation Relief Valve. See 3.3.55.5.1.

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

3.3.10 Diesel Engine. See 3.3.13.1.

3.3.11 Disconnecting Means. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply. [70: Art. 100]

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

3.3.13 Engine.

3.3.13.1 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.

3.3.13.2 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.

3.3.14 Fault Tolerant External Control Circuit. See 3.3.7.2.

3.3.15 Feeder. All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device. [70: Art. 100]

3.3.16 Fire Pump Alarm. A supervisory signal indicating an abnormal condition requiring immediate attention.

3.3.17 Fire Pump Controller. A group of devices that serve to govern, in some predetermined manner, the starting and stopping of the fire pump driver and to monitor and signal the status and condition of the fire pump unit.

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

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

3.3.20 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.

3.3.21 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.

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

3.3.23* 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.

3.3.23.1 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.

3.3.23.2 Total Discharge Head (h_d). 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.

3.3.23.3 Total Head.

3.3.23.3.1* 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.

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

3.3.23.4 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.

3.3.23.5 Total Suction Head. 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.

3.3.23.6* Velocity Head (h_v). 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.

3.3.24 High-Rise Building. A building where the floor of an occupiable story is greater than 75 ft (23 m) above the lowest level of fire department vehicle access. [5000, 2009]

3.3.25 Internal Combustion Engine. See 3.3.13.2.

3.3.26 Isolating Switch. See 3.3.48.1.

3.3.27 Liquid. For the purposes of this standard, liquid refers to water, foam-water solution, foam concentrates, water additives, or other liquids for fire protection purposes.

3.3.28 Liquid Level.

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

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

3.3.29 Loss of Phase. The loss of one or more, but not all, phases of the polyphase power source.

3.3.30 Manual Transfer Switch. See 3.3.48.2.2.

3.3.31 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.

3.3.32 Motor.

3.3.32.1 Dripproof Guarded Motor. A dripproof machine whose ventilating openings are so constructed that successful operation with the definition for dripproof motor.

3.3.32.2 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.

3.3.32.3 Dust-Ignition-Proof Motor. A totally enclosed motor whose enclosure is designed and constructed in a man-

ner 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.

3.3.32.4 Electric Motor. A motor that is classified according to mechanical protection and methods of cooling.

3.3.32.5 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.

3.3.32.6 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.

3.3.32.7 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.

3.3.32.8 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.

3.3.32.9 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.

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

3.3.33 Net Positive Suction Head (NPSH) (h_{sn}). See 3.3.23.1.

3.3.34 On-Site Power Production Facility. The normal supply of electric power for the site that is expected to be constantly producing power.

3.3.35 On-Site Standby Generator. A facility producing electric power on site as the alternate supply of electrical power. It differs from an on-site power production facility in that it is not constantly producing power.

3.3.36 Pressure-Regulating Device. A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure. [14, 2007]

3.3.37 Pump.

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

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

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

3.3.37.4 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.

3.3.37.5 Fire Pump. A pump that is a provider of liquid flow and pressure dedicated to fire protection.

3.3.37.6 Foam Concentrate Pump. See 3.3.37.1, Additive Pump.

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

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

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

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

3.3.37.11 Packaged Fire Pump Assembly. Fire pump unit components assembled at a packaging facility and shipped as a unit to the installation site. The scope of listed components (where required to be listed by this standard) in a pre-assembled package includes the pump, driver, controller, and other accessories identified by the packager assembled onto a base with or without an enclosure.

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

3.3.37.13 Positive Displacement Pump. 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.

3.3.37.14 Pressure Maintenance (Jockey or Make-Up) Pump. A pump designed to maintain the pressure on the fire protection system(s) between preset limits when the system is not flowing water.

3.3.37.15 Rotary Lobe Pump. 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.

3.3.37.16 Rotary Vane Pump. 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.

3.3.37.17 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.

3.3.38 Pumping Liquid Level. See 3.3.28.1.

3.3.39 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill,

and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems related to the subject matter, the work, or the project. [1451, 2007]

3.3.40 Series Fire Pump Unit. All fire pump units that operate in a series arrangement where the first fire pump takes suction directly from a water supply and each sequential pump takes suction from the preceding pump; pumps taking suction from tanks or break tanks are not considered series fire pump units even if fire pumps at lower elevations are used to refill the tanks or break tanks.

3.3.41* Service. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served. [70: Art. 100]

3.3.42* Service Equipment. The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the load end of service conductors to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply. [70: Art. 100]

3.3.43 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.

3.3.44 Set Pressure. As applied to variable speed pressure limiting control systems, the pressure that the variable speed pressure limiting control system is set to maintain.

3.3.45* Signal. An indicator of status.

3.3.46 Speed.

3.3.46.1 Engine Speed. The speed indicated on the engine nameplate.

3.3.46.2 Motor Speed. The speed indicated on the motor nameplate.

3.3.46.3 Rated Speed. The speed for which the fire pump is listed and that appears on the fire pump nameplate.

3.3.47 Static Liquid Level. See 3.3.28.2.

3.3.48 Switch.

3.3.48.1 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.

3.3.48.2 Transfer Switch.

3.3.48.2.1 Automatic Transfer Switch (ATS). Self-acting equipment for transferring the connected load from one power source to another power source. [110, 2010]

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

3.3.49 Total Discharge Head (h_d). See 3.3.23.2.

3.3.50 Total Head (H), Horizontal Pumps. See 3.3.23.3.1.

3.3.51 Total Head (H), Vertical Turbine Pumps. See 3.3.23.3.2.



3.3.52 Total Rated Head. See 3.3.23.4.

3.3.53 Total Suction Head (h_s). See 3.3.23.5.

3.3.54 Total Suction Lift (h_l). Suction lift that 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.

3.3.55 Valve.

3.3.55.1 Dump Valve. An automatic valve installed on the discharge side of a positive displacement pump to relieve pressure prior to the pump driver reaching operating speed.

3.3.55.2 Low Suction Throttling Valve. A pilot-operated valve installed in discharge piping that maintains positive pressure in the suction piping, while monitoring pressure in the suction piping through a sensing line.

3.3.55.3 Pressure Control Valve. A pilot-operated pressure-reducing valve designed for the purpose of reducing the downstream water pressure to a specific value under both flowing (residual) and nonflowing (static) conditions. [14, 2007]

3.3.55.4 Pressure-Reducing Valve. A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions. [14, 2007]

3.3.55.5 Relief Valve. A device that allows the diversion of liquid to limit excess pressure in a system.

3.3.55.5.1 Circulation Relief Valve. A valve used to cool a pump by discharging a small quantity of water; this valve is separate from and independent of the main relief valve.

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

3.3.56 Variable Speed Pressure Limiting Control. A speed control system used to limit the total discharge pressure by reducing the pump driver speed from rated speed.

3.3.57 Variable Speed Suction Limiting Control. A speed control system used to maintain a minimum positive suction pressure at the pump inlet by reducing the pump driver speed while monitoring pressure in the suction piping through a sensing line.

3.3.58 Velocity Head (h_v). See 3.3.23.6.

3.3.59 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.

Chapter 4 General Requirements

4.1 Pumps.

4.1.1 This standard shall apply to centrifugal single-stage and multistage pumps of the horizontal or vertical shaft design and positive displacement pumps of the horizontal or vertical shaft design.

4.1.2 Other Pumps.

4.1.2.1 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.

4.1.2.2 These pumps shall be limited to capacities of less than 500 gpm (1892 L/min).

4.2* Approval Required.

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

4.2.2 The pump manufacturer or its authorized representative shall be given complete information concerning the liquid and power supply characteristics.

4.2.3 A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and liquid supply conditions shall be prepared for approval.

4.2.4 Each pump, driver, controlling equipment, power supply and arrangement, and liquid supply shall be approved by the authority having jurisdiction for the specific field conditions encountered.

4.3 Pump Operation.

4.3.1 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.

4.3.2 System Designer. The system designer shall be identified on the system design documents. Acceptable minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction. Qualified personnel shall include, but not be limited to, one or more of the following:

- (1) Personnel who are factory trained and certified for fire pump system design of the specific type and brand of system being designed
- (2)*Personnel who are certified by a nationally recognized fire protection certification organization acceptable to the authority having jurisdiction
- (3) Personnel who are registered, licensed, or certified by a state or local authority

4.3.2.1 Additional evidence of qualification or certification shall be permitted to be required by the AHJ.

4.3.3 System Installer. Installation personnel shall be qualified or shall be supervised by persons who are qualified in the installation, inspection, and testing of fire protection systems. Minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction. Qualified personnel shall include, but not be limited to, one or more of the following:

- (1) Personnel who are factory trained and certified for fire pump system designed of the specific type and brand of system being designed
- (2)*Personnel who are certified by a nationally recognized fire protection certification organization acceptable to the authority having jurisdiction
- (3) Personnel who are registered, licensed, or certified by a state or local authority

4.3.3.1 Additional evidence of qualification or certification shall be permitted to be required by the AHJ.

4.3.4* Service Personnel Qualifications and Experience.

4.3.4.1 Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of fire protection systems. Qualified personnel shall include, but not be limited to, one or more of the following:

- (1) Personnel who are factory trained and certified for fire pump system design of the specific type and brand of system being designed
- (2)*Personnel who are certified by a nationally recognized fire protection certification organization acceptable to the authority having jurisdiction
- (3) Personnel who are registered, licensed, or certified by a state or local authority
- (4) Personnel who are employed and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire protection systems

4.3.4.2 Additional evidence of qualification or certification shall be permitted to be required by the AHJ.

4.4 Fire Pump Unit Performance.

4.4.1* The fire pump 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.

4.4.2 The complete fire pump unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. (See Section 14.2.)

4.5 Certified Shop Test.

4.5.1 Certified shop test curves showing head capacity and brake horsepower of the pump shall be furnished by the manufacturer to the purchaser.

4.5.2 The purchaser shall furnish the data required in 4.5.1 to the authority having jurisdiction.

4.6 Liquid Supplies.

4.6.1* **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.

4.6.2* Sources.

4.6.2.1 Any source of water that is adequate in quality, quantity, and pressure shall be permitted to provide the supply for a fire pump.

4.6.2.2 Where the water supply from a public service main is not adequate in quality, quantity, or pressure, an alternative water source shall be provided.

4.6.2.3 The adequacy of the water supply shall be determined and evaluated prior to the specification and installation of the fire pump.

4.6.2.3.1 Where the maximum flow available from the water supply cannot provide a flow of 150 percent of the rated flow of the pump, but the water supply can provide the greater of 100 percent of rated flow or the maximum flow demand of the fire protection system(s), the water supply shall be deemed to be adequate. In this case, the maximum flow shall be considered the highest flow that the water supply can achieve.

4.6.2.3.2 Where the water supply cannot provide 150 percent of the rated flow of the pump, a placard shall be placed in the pump room indicating the minimum suction pressure that the

fire pump is allowed to be tested at and also indicating the required flow rate.

4.6.2.4 For liquids other than water, the liquid source for the pump shall be adequate to supply the maximum required flow rate for any simultaneous demands for the required duration and the required number of discharges.

4.6.3 **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.

4.6.4* Stored Supply.

4.6.4.1 A stored supply plus reliable automatic refill shall be sufficient to meet the demand placed upon it for the design duration.

4.6.4.2 A reliable method of replenishing the supply shall be provided.

4.6.5 Head.

4.6.5.1 Except as provided in 4.6.5.2, 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.

4.6.5.2 Where the water supply cannot provide a flow of 150 percent of the rated flow of the pump, but the water supply can provide the flow demand of the fire protection system, the head available from the water supply shall be permitted to be calculated on the basis of the maximum flow available as allowed by 4.6.2.3.1.

4.6.5.3 This head shall be as indicated by a flow test.

4.7 Pumps, Drivers, and Controllers.

4.7.1* Fire pumps shall be dedicated to and listed for fire protection service.

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

4.7.3* A pump shall not be equipped with more than one driver.

4.7.4 Each fire pump shall have its own dedicated driver unless otherwise permitted in 8.5.3.1.

4.7.5 Each driver shall have its own dedicated controller.

4.7.6* The driver shall be selected in accordance with 9.5.2 (electric motors), 11.2.2 (diesel engines), or 13.1.2 (steam turbines) to provide the required power to operate the pump at rated speed and maximum pump load under any flow condition.

4.7.7* Maximum Pressure for Centrifugal Pumps.

4.7.7.1 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.

4.7.7.2* Pressure relief valves and pressure regulating devices in the fire pump installation shall not be used as a means to meet the requirements of 4.7.7.1.

4.7.7.3 Variable Speed Pressure Limiting Control.

4.7.7.3.1 Variable speed pressure limiting control drivers, as defined in this standard, shall be acceptable to limit system pressure.

4.7.7.3.2* The set pressure plus the maximum pressure variance of the variable speed pressure limiting controlled systems



during variable speed operation and adjusted for elevation shall not exceed the pressure rating of any system component.

4.8* Centrifugal Fire Pump Capacities.

4.8.1 A centrifugal fire pump for fire protection shall be selected so that the greatest single demand for any fire protection system connected to the pump is less than or equal to 150 percent of the rated capacity (flow) of the pump.

4.8.2* Centrifugal fire pumps shall have one of the rated capacities in gpm (L/min) identified in Table 4.8.2 and shall be rated at net pressures of 40 psi (2.7 bar) or more.

Table 4.8.2 Centrifugal Fire Pump Capacities

gpm	L/min	gpm	L/min
25	95	1,000	3,785
50	189	1,250	4,731
100	379	1,500	5,677
150	568	2,000	7,570
200	757	2,500	9,462
250	946	3,000	11,355
300	1,136	3,500	13,247
400	1,514	4,000	15,140
450	1,703	4,500	17,032
500	1,892	5,000	18,925
750	2,839		

4.8.3 Centrifugal fire pumps with ratings over 5000 gpm (18,925 L/min) shall be subject to individual review by either the authority having jurisdiction or a listing laboratory.

4.9 Nameplate. Pumps shall be provided with a nameplate.

4.10 Pressure Gauges.

4.10.1 Discharge.

4.10.1.1 A pressure gauge having a dial not less than 3.5 in. (89 mm) in diameter shall be connected near the discharge casting with a nominal 0.25 in. (6 mm) gauge valve.

4.10.1.2 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).

4.10.1.3 The face of the dial shall read in bar, pounds per square inch, or both with the manufacturer's standard graduations.

4.10.2* Suction.

4.10.2.1 Unless the requirements of 4.10.2.4 are met, a gauge having a dial not less than 3.5 in. (89 mm) in diameter shall be connected to the suction pipe near the pump with a nominal 0.25 in. (6 mm) gauge valve.

4.10.2.1.1 Where the minimum pump suction pressure is below 20 psi (1.3 bar) under any flow condition, the suction gauge shall be a compound pressure and vacuum gauge.

4.10.2.2 The face of the dial shall read in inches of mercury (millimeters of mercury) or psi (bar) for the suction range.

4.10.2.3 The gauge shall have a pressure range two times the rated maximum suction pressure of the pump.

4.10.2.4 The requirements of 4.10.2 shall not apply to vertical shaft turbine-type pumps taking suction from a well or open wet pit.

4.11 Circulation Relief Valve.

4.11.1 Automatic Relief Valve.

4.11.1.1 Unless the requirements of 4.11.1.7 are met, 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.

4.11.1.2 The valve shall be installed on the discharge side of the pump before the discharge check valve.

4.11.1.3 The valve shall provide flow of sufficient water to prevent the pump from overheating when operating with no discharge.

4.11.1.4 Provisions shall be made for discharge to a drain.

4.11.1.5 Circulation relief valves shall not be tied in with the packing box or drip rim drains.

4.11.1.6 The automatic relief valve shall have a nominal size of 0.75 in. (19 mm) for pumps with a rated capacity not exceeding 2500 gpm (9462 L/min) and have a nominal size of 1 in. (25 mm) for pumps with a rated capacity of 3000 gpm to 5000 gpm (11,355 L/min to 18,925 L/min).

4.11.1.7 The requirements of 4.11.1 shall not apply to engine-driven pumps for which engine cooling water is taken from the pump discharge.

4.12* Equipment Protection.

4.12.1* General Requirements. The fire pump, driver, controller, water supply, and power supply 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.

4.12.1.1* Indoor Fire Pump Units.

4.12.1.1.1 Fire pump units serving high-rise buildings shall be protected from surrounding occupancies by a minimum of 2-hour fire-rated construction or physically separated from the protected building by a minimum of 50 ft (15.3 m).

4.12.1.1.2 Indoor fire pump rooms in non-high-rise buildings or in separate fire pump buildings shall be physically separated or protected by fire-rated construction in accordance with Table 4.12.1.1.2.

4.12.1.1.3 The location of and access to the fire pump room shall be preplanned with the fire department.

Table 4.12.1.1.2 Equipment Protection

Pump Room/House	Building(s) Exposing Pump Room/House	Required Separation
Not sprinklered	Not sprinklered	2 hour fire-rated or 50 ft (15.3 m)
Not sprinklered	Fully sprinklered	
Fully sprinklered	Not sprinklered	
Fully sprinklered	Fully sprinklered	1 hour fire-rated or 50 ft (15.3 m)



4.12.1.1.4* Except as permitted in 4.12.1.1.5, rooms containing fire pumps shall be free from storage, equipment, and penetrations not essential to the operation of the pump and related components.

4.12.1.1.5 Equipment related to domestic water distribution shall be permitted to be located within the same room as the fire pump equipment.

4.12.1.2 Outdoor Fire Pump Units.

4.12.1.2.1 Fire pump units that are outdoors shall be located at least 50 ft (15.3 m) away from any buildings and other fire exposures exposing the building.

4.12.1.2.2 Outdoor installations shall be required to be provided with protection against possible interruption, in accordance with 4.12.1.

4.12.1.3 Fire Pump Buildings or Rooms with Diesel Engines. Fire pump buildings or rooms enclosing diesel engine pump drivers and day tanks shall be protected with an automatic sprinkler system installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

4.12.2 Equipment Access.

4.12.2.1 Access to the fire pump room shall be pre-planned with the fire department.

4.12.2.1.1 Fire pump rooms not directly accessible from the outside shall be accessible through an enclosed passageway from an enclosed stairway or exterior exit. The enclosed passageway shall have a minimum 2-hour fire-resistance rating.

4.12.3 Heat.

4.12.3.1 An approved or listed source of heat shall be provided for maintaining the temperature of a pump room or pump house, where required, above 40°F (5°C).

4.12.3.2 The requirements of 11.6.5 shall be followed for higher temperature requirements for internal combustion engines.

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

4.12.5 Emergency Lighting.

4.12.5.1 Emergency lighting shall be provided in accordance with NFPA 101, *Life Safety Code*.

4.12.5.2 Emergency lights shall not be connected to an engine starting battery.

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

4.12.7* Drainage.

4.12.7.1 Floors shall be pitched for adequate drainage of escaping water away from critical equipment such as the pump, driver, controller, and so forth.

4.12.7.2 The pump room or pump house shall be provided with a floor drain that will discharge to a frost-free location.

4.12.8 Guards. Couplings and flexible connecting shafts shall be installed with a coupling guard in accordance with Section 8 of ANSI B15.1, *Safety Standard for Mechanical Power Transmission Apparatus*.

4.13 Pipe and Fittings.

4.13.1* Steel Pipe.

4.13.1.1 Steel pipe shall be used aboveground except for connection to underground suction and underground discharge piping.

4.13.1.2 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.

4.13.1.3 Thick bituminous linings shall not be used.

4.13.2* Joining Method.

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

4.13.2.2 Slip-type fittings shall be permitted to be used where installed as required by 4.14.6 and where the piping is mechanically secured to prevent slippage.

4.13.3 Concentrate and Additive Piping.

4.13.3.1 Foam concentrate or additive piping shall be a material that will not corrode in this service.

4.13.3.2 Galvanized pipe shall not be used for foam concentrate service.

4.13.4 Drain Piping. Drain pipe and its fittings that discharge to atmosphere shall be permitted to be constructed of metallic or polymeric materials.

4.13.5 Piping, Hangers, and Seismic Bracing. Pipe, fittings, hangers, and seismic bracing for the fire pump unit, including the suction and discharge piping, shall comply with the applicable requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*.

4.13.6* Cutting and Welding. 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*.

4.14 Suction Pipe and Fittings.

4.14.1* Components.

4.14.1.1 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.

4.14.1.2 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.

4.14.2 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*.

4.14.3 Suction Size.

4.14.3.1* Unless the requirements of 4.14.3.2 are met, 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 maximum flow (150 percent of rated capacity or the maximum flow available from the water supply as discussed in 4.6.2.3.1), the gauge pressure at the pump suction flanges shall be 0 psi (0 bar) or higher.



4.14.3.2 The requirements of 4.14.3.1 shall not apply where the supply is a suction tank with its base at or above the same elevation as the pump, where the gauge pressure at the pump suction flange shall be permitted to drop to -3 psi (-0.2 bar) with the lowest water level after the maximum system demand and duration have been supplied.

4.14.3.3 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).

4.14.3.4 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 Section 4.26.

4.14.4* Pumps with Bypass.

4.14.4.1 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.4.14.4.)

4.14.4.2 The size of the bypass shall be at least as large as the pipe size required for discharge pipe as specified in Section 4.26.

4.14.5* Valves.

4.14.5.1 A listed outside screw and yoke (OS&Y) gate valve shall be installed in the suction pipe.

4.14.5.2 No valve other than a listed OS&Y valve shall be installed in the suction pipe within 50 ft (15.3 m) of the pump suction flange.

4.14.6* Installation.

4.14.6.1 General. Suction pipe shall be laid carefully to avoid air leaks and air pockets, either of which can seriously affect the operation of the pump.

4.14.6.2 Freeze Protection.

4.14.6.2.1 Suction pipe shall be installed below the frost line or in frostproof casings.

4.14.6.2.2 Where pipe enters streams, ponds, or reservoirs, special attention shall be given to prevent freezing either underground or underwater.

4.14.6.3 Elbows and Tees.

4.14.6.3.1 Unless the requirements of 4.14.6.3.2 are met, elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft shall not be permitted. (See Figure A.4.14.6.)

4.14.6.3.2 The requirements of 4.14.6.3.1 shall not apply to elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft 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.

4.14.6.3.3 Elbows with a centerline plane perpendicular to the horizontal split-case pump shaft shall be permitted at any location in the pump suction intake.

4.14.6.4 Eccentric Tapered Reducer or Increaser. 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.

4.14.6.5 Strain Relief. 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.6.3.1(a).)

4.14.7 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.

4.14.8* Suction Screening.

4.14.8.1 Where the water supply is obtained from an open source such as a pond or wet pit, the passage of materials that might clog the pump shall be obstructed.

4.14.8.2 Double intake screens shall be provided at the suction intake.

4.14.8.3 Screens shall be removable, or an in situ cleaning shall be provided.

4.14.8.4 Below minimum water level, these screens shall have an effective net area of opening of 1 in.² for each 1 gpm (170 mm² for each 1 L/min) at 150 percent of rated pump capacity.

4.14.8.5 Screens shall be so arranged that they can be cleaned or repaired without disturbing the suction pipe.

4.14.8.6 Mesh screens shall be brass, copper, Monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of 0.50 in. (12.7 mm) maximum mesh and No. 10 B&S gauge.

4.14.8.7 Where flat panel mesh screens are used, the wire shall be secured to a metal frame sliding vertically at the entrance to the intake.

4.14.8.8 Where the screens are located in a sump or depression, they shall be equipped with a debris-lifting rake.

4.14.8.9 Periodically, the system shall be test pumped, the screens shall be removed for inspection, and accumulated debris shall be removed.

4.14.8.10 Continuous slot screens shall be brass, copper, Monel, stainless steel, or other equivalent corrosion-resistant metallic material of 0.125 in. (3.2 mm) maximum slot and profile wire construction.

4.14.8.11 Screens shall have at least 62.5 percent open area.

4.14.8.12 Where zebra mussel infestation is present or reasonably anticipated at the site, the screens shall be constructed of a material with demonstrated resistance to zebra mussel attachment or coated with a material with demonstrated resistance to zebra mussel attachment at low velocities.

4.14.8.13 The overall area of the screen shall be 1.6 times the net screen opening area. (See screen details in Figure A.7.2.2.2.)

4.14.9* Devices in Suction Piping.

4.14.9.1 No device or assembly, unless identified in 4.14.9.2, that will stop, restrict the starting of, or restrict the discharge of a fire pump or pump driver shall be installed in the suction piping.

4.14.9.2 The following devices shall be permitted in the suction piping where the following requirements are met:

- (1) Check valves and backflow prevention devices and assemblies shall be permitted where required by other NFPA standards or the authority having jurisdiction.
- (2) Where the authority having jurisdiction requires positive pressure to be maintained on the suction piping, a pressure sensing line for a low suction pressure control, specifically listed for fire pump service, shall be permitted to be connected to the suction piping.

- (3) Devices shall be permitted to be installed in the suction supply piping or stored water supply and arranged to activate a signal if the pump suction pressure or water level falls below a predetermined minimum.
- (4) Suction strainers shall be permitted to be installed in the suction piping where required by other sections of this standard.
- (5) Other devices specifically permitted or required by this standard shall be permitted.

4.14.10* 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.6.3.1(a).]

4.15 Discharge Pipe and Fittings.

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

4.15.2 The pressure rating of the discharge components shall be adequate for the maximum total discharge head with the pump operating at shutoff and rated speed but shall not be less than the rating of the fire protection system.

4.15.3* Steel pipe with flanges, screwed joints, or mechanical grooved joints shall be used above ground.

4.15.4 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*.

4.15.5* The size of pump discharge pipe and fittings shall not be less than that given in Section 4.26.

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

4.15.7 A listed indicating gate or butterfly valve shall be installed on the fire protection system side of the pump discharge check valve.

4.15.8 Where pumps are installed in series, a butterfly valve shall not be installed between pumps.

4.15.9 Low Suction Pressure Controls.

4.15.9.1 Low suction throttling valves or variable speed suction limiting controls for pump drivers 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.

4.15.9.2 When a low suction throttling valve is used, it shall be installed according to manufacturers' recommendations in the piping between the pump and the discharge check valve.

4.15.9.3* The size of the low suction throttling valve shall not be less than that given for discharge piping in Section 4.26.

4.15.10* Pressure Regulating Devices. No pressure regulating devices shall be installed in the discharge pipe except as permitted in this standard.

4.16* Valve Supervision.

4.16.1 Supervised Open. 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

4.16.2 Supervised Closed. The test outlet control valves shall be supervised closed.

4.17* Protection of Piping Against Damage Due to Movement. A clearance of not less than 1 in. (25 mm) shall be provided around pipes that pass through walls or floors.

4.18 Relief Valves for Centrifugal Pumps.

4.18.1* General.

4.18.1.1 Where a diesel engine fire pump is installed and where a total of 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 pressure relief valve shall be installed.

4.18.1.2* Pressure relief valves shall be used only where specifically permitted by this standard.

4.18.1.3 Where an electric variable speed pressure limiting control driver is installed, and the maximum total discharge head adjusted for elevation with the pump operating at shutoff and rated speed exceeds the pressure rating of the system components, a pressure relief valve shall be installed.

4.18.2 Size. The relief valve size shall be determined by one of the methods specified in 4.18.2.1 or 4.18.2.2.

4.18.2.1* The relief valve shall be permitted to be sized hydraulically to discharge sufficient water to prevent the pump discharge pressure, adjusted for elevation, from exceeding the pressure rating of the system components.

4.18.2.2 If the relief valve is not sized hydraulically, the relief valve size shall not be less than that given in Section 4.26. (See also 4.18.7 and A.4.18.7 for conditions that affect size.)

4.18.3 Location. 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.

4.18.4 Type.

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

4.18.4.2 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.

4.18.5* Discharge.

4.18.5.1 The relief valve shall discharge into an open pipe or into a cone or funnel secured to the outlet of the valve.

4.18.5.2 Water discharge from the relief valve shall be readily visible or easily detectable by the pump operator.

4.18.5.3 Splashing of water into the pump room shall be avoided.

4.18.5.4 If a closed-type cone is used, it shall be provided with means for detecting motion of water through the cone.



4.18.5.5 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.

4.18.6 Discharge Piping.

4.18.6.1 Except as permitted in 4.18.6.2, the relief valve discharge pipe shall be of a size not less than that given in Section 4.26.

4.18.6.2 The discharge pipe shall be permitted to be sized hydraulically to discharge sufficient water to prevent the pump discharge pressure, adjusted for elevation, from exceeding the pressure rating of the system components.

4.18.6.2.1 If the pipe employs more than one elbow, the next larger pipe size shall be used.

4.18.6.3 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.

4.18.7* Discharge to Source of Supply. 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.

4.18.7.1 Where a pressure relief valve has been piped back to suction, a circulation relief valve sized in accordance with 4.11.1.6 and discharged to atmosphere shall be provided downstream of the pressure relief valve.

4.18.8* Discharge to Suction Reservoir. 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.

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

4.19 Pumps Arranged in Series.

4.19.1 Series Fire Pump Unit Performance.

4.19.1.1 A series fire pump unit (pumps, drivers, controllers, and accessories) shall perform in compliance with this standard as an entire unit.

4.19.1.2 Within 20 seconds after a demand to start, pumps in series shall supply and maintain a stable discharge pressure (± 10 percent) throughout the entire range of operation.

4.19.1.2.1 The discharge pressure shall be permitted to be adjusted and restabilized whenever the flow condition changes.

4.19.1.3 The complete series fire pump unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. (See Section 14.2.)

4.19.2 Fire Pump Arrangement.

4.19.2.1 No more than three pumps shall be allowed to operate in series.

4.19.2.2 No pump in a series pump unit shall be shut down automatically for any condition of suction pressure.

4.19.2.3 No pressure reducing or pressure regulating valves shall be installed between fire pumps arranged in series.

4.19.2.4 The pressure at any point in any pump in a series fire pump unit, with all pumps running at shutoff and rated speed

at the maximum static suction supply, shall not exceed any pump suction, discharge, or case working pressure rating.

4.20 Water Flow Test Devices.

4.20.1 General.

4.20.1.1* 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.

4.20.1.2* Where water usage or discharge is not permitted for the duration of the test specified in Chapter 14, the outlet shall be used to test the pump and suction supply and determine that the system is operating in accordance with the design.

4.20.1.3 The flow shall continue until the flow has stabilized. (See 14.2.5.4.)

4.20.1.4 Where a test header is installed, it shall be installed on an exterior wall or in another location outside the pump room that allows for water discharge during testing in accordance with 14.2.7.2.

4.20.2 Meters and Testing Devices.

4.20.2.1 Testing Devices.

4.20.2.1.1* Metering devices or fixed nozzles for pump testing shall be listed.

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

4.20.2.3 All of the meter system piping shall be permitted to be sized hydraulically but shall not be smaller than as specified by the meter manufacturer.

4.20.2.4 If the meter system piping is not sized hydraulically, then 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 Section 4.26.

4.20.2.5 For nonhydraulically sized piping, 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 (30.5 m) equivalent length.

4.20.2.6 For nonhydraulically sized piping, where meter system piping exceeds 100 ft (30.5 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.

4.20.2.7 The primary element shall be suitable for that pipe size and pump rating.

4.20.2.8 The readout instrument shall be sized for the pump-rated capacity. (See Section 4.26.)

4.20.2.9 When discharging back into a tank, the discharge nozzle(s) or pipe shall be located at a point as far from the pump suction as is necessary to prevent the pump from drafting air introduced by the discharge of test water into the tank.

4.20.3 Hose Valves.

4.20.3.1* General.

4.20.3.1.1 Hose valves shall be listed.

4.20.3.1.2 The number and size of hose valves used for pump testing shall be as specified in Section 4.26.

4.20.3.1.3 Where outlets are being utilized as a means to test the fire pump in accordance with 4.20.1.1, one of the following methods shall be used:

- (1)*Hose valves mounted on a hose valve header with supply pipe sized in accordance with 4.20.3.4 and Section 4.26
- (2) Wall hydrants, yard hydrants, or standpipe outlets of sufficient number and size to allow testing of the pump

4.20.3.2 Thread Type. Thread types shall be in compliance with one of the following:

- (1) Hose valve(s) shall have the NH standard external thread for the valve size specified, as stipulated in NFPA 1963, *Standard for Fire Hose Connections*.
- (2) Where local fire department connections do not conform to NFPA 1963, the authority having jurisdiction shall designate the threads to be used.

4.20.3.3 Location.

4.20.3.3.1 Where the hose valve header is located outside or at a distance from the pump and there is danger of freezing, a listed indicating butterfly or gate valve and drain valve or ball drip shall be located in the pipeline to the hose valve header.

4.20.3.3.2 The valve required in 4.20.3.3.1 shall be at a point in the line close to the pump. (See Figure A.6.3.1(a).)

4.20.3.4 Pipe Size. The pipe size shall be in accordance with one of the following two methods:

- (1) Where the pipe between the hose valve header and the connection to the pump discharge pipe is over 15 ft (4.5 m) in length, the next larger pipe size than that required by 4.20.3.1.3 shall be used.
- (2)*This pipe is permitted to be sized by hydraulic calculations based on a total flow of 150 percent of rated pump capacity, including the following:
 - (a) 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.
 - (b) The installation shall be proven by a test flowing the maximum water available.

4.21 Steam Power Supply Dependability.

4.21.1 Steam Supply.

4.21.1.1 Careful consideration shall be given in each case to the dependability of the steam supply and the steam supply system.

4.21.1.2 Consideration shall include the possible effect of interruption of transmission piping either on the property or in adjoining buildings that could threaten the property.

4.22 Shop Tests.

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

4.22.2 Preshipment Tests.

4.22.2.1 Before shipment from the factory, each pump shall be hydrostatically tested by the manufacturer for a period of not less than 5 minutes.

4.22.2.2 The test pressure shall not be less than one and one-half times the sum of the pump's shutoff head plus its maxi-

mum allowable suction head, but in no case shall it be less than 250 psi (17.24 bar).

4.22.2.3 Pump casings shall be essentially tight at the test pressure.

4.22.2.4 During the test, no objectionable leakage shall occur at any joint.

4.22.2.5 In the case of vertical turbine-type pumps, both the discharge casting and pump bowl assembly shall be tested.

4.23* Pump Shaft Rotation. Pump shaft rotation shall be determined and correctly specified when fire pumps and equipment involving that rotation are ordered.

4.24* Other Signals. Where required by other sections of this standard, signals shall call attention to improper conditions in the fire pump equipment.

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

4.25.1 Pressure maintenance pumps shall not be required to be listed. Pressure maintenance pumps shall be approved.

4.25.1.1* The pressure maintenance pump shall be sized to replenish the fire protection system pressure due to allowable leakage and normal drops in pressure.

4.25.2 Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate.

4.25.3 Pressure maintenance pumps shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

4.25.4* Excess Pressure.

4.25.4.1 Where a centrifugal-type pressure maintenance pump has a total discharge pressure with the pump operating at shutoff 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.

4.25.4.2 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.

4.25.5 Piping and Components for Pressure Maintenance Pumps.

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

4.25.5.2 Valves and components for the pressure maintenance pump shall not be required to be listed.

4.25.5.3 An isolation valve shall be installed on the suction side of the pressure maintenance pump to isolate the pump for repair.

4.25.5.4 A check valve and isolation valve shall be installed in the discharge pipe.

4.25.5.5* Indicating valves shall be installed in such places as needed to make the pump, check valve, and miscellaneous fittings accessible for repair.

4.25.5.6 The pressure sensing line for the pressure maintenance pump shall be in accordance with Section 4.30.



4.25.5.7 The isolation valves serving the pressure maintenance pump shall not be required to be supervised.

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

4.25.7 The controller for a pressure maintenance pump shall be listed but shall not be required to be listed for fire pump service.

4.25.8 The pressure maintenance pump is not required to have secondary or standby power.

4.26 Summary of Centrifugal Fire Pump Data. The sizes indicated in Table 4.26(a) and Table 4.26(b) shall be used as a minimum.

4.27 Backflow Preventers and Check Valves.

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

4.27.2 Relief Valve Drainage.

4.27.2.1 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 from the relief valve.

4.27.2.2 An air gap shall be provided in accordance with the manufacturer's recommendations.

4.27.2.3 Water discharge from the relief valve shall be readily visible or easily detectable.

4.27.2.4 Performance of the requirements in 4.27.2.1 through 4.27.2.3 shall be documented by engineering calculations and tests.

4.27.3 Devices in Suction Piping. 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.

4.27.3.1 Where a backflow preventer with butterfly control valves is installed in the suction pipe, the backflow preventer is required to be at least 50 ft (15.2 m) from the pump suction flange (as measured along the route of pipe) in accordance with 4.14.5.2.

4.27.4 Evaluation.

4.27.4.1 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.

Table 4.26(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

Pump Rating (gpm)	Minimum Pipe Sizes (Nominal) (in.)						Hose Header Supply
	Suction* [†]	Discharge*	Relief Valve	Relief Valve Discharge	Meter Device	Number and Size of Hose Valves	
25	1	1	¾	1	1¼	1 — 1½	1
50	1½	1¼	1¼	1½	2	1 — 1½	1½
100	2	2	1½	2	2½	1 — 2½	2½
150	2½	2½	2	2½	3	1 — 2½	2½
200	3	3	2	2½	3	1 — 2½	2½
250	3½	3	2	2½	3½	1 — 2½	3
300	4	4	2½	3½	3½	1 — 2½	3
400	4	4	3	5	4	2 — 2½	4
450	5	5	3	5	4	2 — 2½	4
500	5	5	3	5	5	2 — 2½	4
750	6	6	4	6	5	3 — 2½	6
1000	8	6	4	8	6	4 — 2½	6
1250	8	8	6	8	6	6 — 2½	8
1500	8	8	6	8	8	6 — 2½	8
2000	10	10	6	10	8	6 — 2½	8
2500	10	10	6	10	8	8 — 2½	10
3000	12	12	8	12	8	12 — 2½	10
3500	12	12	8	12	10	12 — 2½	12
4000	14	12	8	14	10	16 — 2½	12
4500	16	14	8	14	10	16 — 2½	12
5000	16	14	8	14	10	20 — 2½	12

Notes:

(1) The pressure relief valve shall be permitted to be sized in accordance with 4.18.2.1.

(2) The pressure relief valve discharge shall be permitted to be sized in accordance with 4.18.6.2.

(3) The flowmeter device shall be permitted to be sized in accordance with 4.19.2.2.

(4) The hose header supply shall be permitted to be sized in accordance with 4.19.3.4.

*Actual diameter of pump flange is permitted to be different from pipe diameter.

[†]Applies only to that portion of suction pipe specified in 4.14.3.4.

Table 4.26(b) Summary of Centrifugal Fire Pump Data (Metric)

Pump Rating (L/min)	Minimum Pipe Sizes (Nominal) (mm)						
	Suction*†	Discharge*	Relief Valve	Relief Valve Discharge	Meter Device	Number and Size of Hose Valves	Hose Header Supply
95	25	25	19	25	32	1 — 38	25
189	38	32	32	38	50	1 — 38	38
379	50	50	38	50	65	1 — 65	65
568	65	65	50	65	75	1 — 65	65
757	75	75	50	65	75	1 — 65	65
946	85	75	50	65	85	1 — 65	75
1,136	100	100	65	85	85	1 — 65	75
1,514	100	100	75	125	100	2 — 65	100
1,703	125	125	75	125	100	2 — 65	100
1,892	125	125	100	125	125	2 — 65	100
2,839	150	150	100	150	125	3 — 65	150
3,785	200	150	150	200	150	4 — 65	150
4,731	200	200	150	200	150	6 — 65	200
5,677	200	200	150	200	200	6 — 65	200
7,570	250	250	150	250	200	6 — 65	200
9,462	250	250	200	250	200	8 — 65	250
11,355	300	300	200	300	200	12 — 65	250
13,247	300	300	200	300	250	12 — 65	300
15,140	350	300	200	350	250	16 — 65	300
17,032	400	350	200	350	250	16 — 65	300
18,925	400	350	200	350	250	20 — 65	300

Notes:

- (1) The pressure relief valve shall be permitted to be sized in accordance with 4.18.2.1.
- (2) The pressure relief valve discharge shall be permitted to be sized in accordance with 4.18.6.2.
- (3) The flow meter device shall be permitted to be sized in accordance with 4.19.2.2.
- (4) The hose header supply shall be permitted to be sized in accordance with 4.19.3.4.

*Actual diameter of pump flange is permitted to be different from pipe diameter.

†Applies only to that portion of suction pipe specified in 4.14.3.4.

4.27.4.2 Where a backflow prevention device is installed, 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.

4.27.4.3 If available suction supplies do not permit the flowing of 150 percent of rated pump capacity, the final arrangement of the backflow prevention device shall provide effective pump performance with a minimum suction pressure of 0 psi (0 bar) at the gauge at the maximum allowable discharge.

4.27.4.4 The discharge shall exceed the fire protection system design flow.

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

4.28 Earthquake Protection.

4.28.1* Unless the requirements of 4.28.2 are met and 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 the weight of the equipment.

4.28.2 The requirements of 4.28.1 shall not apply where the authority having jurisdiction requires horizontal force factors other than 0.5; in such cases, NFPA 13, *Standard for the Installation of Sprinkler Systems*, shall apply for seismic design.

4.28.3 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 4.28.1 or 4.28.2, whichever is applicable.

4.28.4 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.

4.29 Packaged Fire Pump Assemblies.

4.29.1 A packaged pump house and/or skid unit[s] shall include detailed design information acceptable to the authority having jurisdiction.

4.29.2 All electrical components, clearances, and wiring shall meet the minimum requirements of the applicable NFPA 70, *National Electrical Code*, articles.

4.29.3 Packaged and prefabricated skid unit(s) shall meet all the requirements in this standard, including those described in Sections 4.12 through 4.17.

4.29.4 Careful consideration shall be given to the possible effects of system component damage during shipment to the project site.

4.29.4.1 The structural integrity shall be maintained with minimal flexing and movement.

4.29.4.2 The necessary supports and restraints shall be installed to prevent damage and breakage during transit.

4.29.5 The packaged fire pump shall have the correct lifting points marked to ensure safe rigging of the unit.

4.29.6 All packaged pump house and/or pump skids shall meet the requirements of Section 4.28 through 4.28.4.

4.29.7 Suction and discharge piping shall be thoroughly inspected, including checking all flanged and mechanical connections per manufacturers' recommendations, after the pump house or skid unit is set in place on the permanent foundation.

4.29.8 The units shall be properly anchored and grouted in accordance with Section 6.4.

4.29.9* The interior floor shall be solid with grading to provide for proper drainage for the fire pump components. The structural frame for a packaged pump shall be mounted to a properly engineered footing designed to withstand the live loads of the packaged unit and the applicable wind loading requirements. The foundation footings shall include the necessary anchor points required to secure the package to the foundation.

4.29.10 A high skid-resistant, solid structural plate floor with grout holes shall be permitted to be used where protected from corrosion and drainage is provided for all incidental pump room spillage or leakage.

4.30* Pressure Actuated Controller Pressure Sensing Lines.

4.30.1 For all pump installations, including jockey pumps, each controller shall have its own individual pressure sensing line.

4.30.2 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.

4.30.3* The pressure sensing line shall be brass, rigid copper pipe Types K, L, or M, or Series 300 stainless steel pipe or tube, and the fittings shall be of ½ in. (15 mm) nominal size.

4.30.4 Check Valves or Ground-Face Unions.

4.30.4.1 Where the requirements of 4.30.4.2 are not met, there shall be two check valves installed in the pressure sensing line at least 5 ft (1.52 m) apart with a nominal 0.09375 in. (2.4 mm) hole drilled in the clapper to serve as dampening. [See Figure A.4.30(a) and Figure A.4.30(b).]

4.30.4.2 Where the water is clean, ground-face unions with noncorrosive diaphragms drilled with a nominal 0.09375 in. (2.4 mm) orifice shall be permitted in place of the check valves.

4.30.5 Shutoff Valve. There shall be no shutoff valve in the pressure sensing line.

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

4.31 Break Tanks. Where a break tank is used to provide the pump suction water supply, the installation shall comply with this section.

4.31.1 Application. Break tanks shall be used for one or more of the following reasons:

- (1) As a backflow prevention device between the water supply and the fire pump suction pipe
- (2) To eliminate fluctuations in the water supply pressure and provide a steady suction pressure to the fire pump
- (3) To provide a quantity of stored water on site where the normal water supply will not provide the required quantity of water required by the fire protection system

4.31.2 Break Tank Size. The tank shall be sized for a minimum duration of 15 minutes with the fire pump operating at 150 percent of rated capacity.

4.31.3 Refill Mechanism. The refill mechanism shall be listed and arranged for automatic operation.

4.31.3.1 If the break tank capacity is less than the maximum system demand for 30 minutes, the refill mechanism shall meet the requirements in 4.31.3.1.1 through 4.31.3.1.5.

4.31.3.1.1 Dual automatic refill lines, each capable of refilling the tank at a minimum rate of 150 percent of the fire pump(s) capacity, shall be installed.

4.31.3.1.2 If available supplies do not permit refilling the tank at a minimum rate of 150 percent of the rated pump capacity, each refill line shall be capable of refilling the tank at a rate that meets or exceeds 110 percent of the maximum fire protection system design flow.

4.31.3.1.3 A manual tank fill bypass designed for and capable of refilling the tank at a minimum rate of 150 percent of the fire pump(s) capacity shall be provided.

4.31.3.1.4 If available supplies do not permit refilling the tank at a minimum rate of 150 percent of the rated pump capacity, the manual fill bypass shall be capable of refilling the tank at a rate that meets or exceeds 110 percent of the maximum fire protection system design flow.

4.31.3.1.5 A local visible and audible low liquid level signal shall be provided in the vicinity of the tank fill mechanism.

4.31.3.2 If the break tank is sized to provide a minimum duration of 30 minutes of the maximum system demand, the refill mechanism shall meet the requirements in 4.31.3.2.1 through 4.31.3.2.5.

4.31.3.2.1 The refill mechanism shall be designed for and capable of refilling the tank at 110 percent of the rate required to provide the total fire protection system demand $[110\% \times (\text{Total Demand} - \text{Tank Capacity}) / \text{Duration}]$.

4.31.3.2.2 A manual tank fill bypass shall be designed for and capable of refilling the tank at 110 percent of the rate required to provide the total fire protection system demand $[110\% \times (\text{Total Demand} - \text{Tank Capacity}) / \text{Duration}]$.

4.31.3.2.3 The pipe between the municipal connection and the automatic fill valve shall be installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

4.31.3.2.4 The automatic filling mechanism shall be maintained at a minimum temperature of 40°F (4.4°C).

4.31.3.2.5 The automatic filling mechanism shall activate a maximum of 6 in. (152 mm) below the overflow level.

4.31.4 Installation Standard. The break tank shall be installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

4.32 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 14.)

5.7.3.2 Water tank(s) shall be sized for the full fire protection demand and arranged so that at least 50 percent of the fire protection demand is stored with any one compartment or tank out of service.

5.7.3.3 An automatic refill valve shall be provided for each tank or tank compartment.

5.7.3.4 A manual refill valve shall be provided.

5.7.3.5 Each refill valve shall be sized and arranged to independently supply the system fire protection demand.

Chapter 5 Fire Pumps for High-Rise Buildings

5.1 General.

5.1.1 Application.

5.1.1.1 This chapter applies to all fire pumps within a building wherever a building is defined as high-rise per 3.3.24.

5.1.1.2 The provisions of all other chapters of this standard shall apply unless specifically addressed by this chapter.

5.2 Types.

5.2.1 Fire pumps used for high-rise application shall be of a type addressed by Chapter 6 or 7 (centrifugal pumps) of this standard.

5.2.2 Fire pumps complying with Chapter 8 (positive displacement pumps) shall be allowed for local applications.

5.3 Equipment Access. Location and access to the fire pump room shall be preplanned with the fire department.

5.4 Fire Pump Test Arrangement. Where the water supply to a fire pump is a tank, a listed flowmeter or a test header discharging back into the tank with a calibrated nozzle(s) arranged for the attachment of a pressure gauge to determine pitot pressure shall be permitted.

5.5 Auxiliary Power. Where electric motors are used and the height of the structure is beyond the pumping capability of the fire department apparatus, a reliable emergency source of power in accordance with Section 9.6 shall be provided for the fire pump installation.

5.6* Fire Pump Backup. Fire pumps serving zones that are partially or wholly beyond the pumping capability of the fire department apparatus shall be provided with an auxiliary means that is capable of providing the full fire protection demand.

5.7 Water Supply Tanks.

5.7.1 Water tanks shall be installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

5.7.2 When a water tank serves domestic and fire protection systems, the domestic supply connection shall be connected above the level required for fire protection demand.

5.7.3 Water tanks supplying suction to fire pumps serving zones that are partially or wholly beyond the pumping capability of the fire department apparatus shall meet the requirements in 5.7.3.1 through 5.7.3.5 with a minimum of two automatic fill valves with separate piping connected to the zone below or primary water supply to the building. A manual fill valve shall also be provided.

5.7.3.1 Two or more water tanks shall be provided. Alternatively, a water tank shall be permitted to be divided into compartments such that the compartments function as individual tanks.

Chapter 6 Centrifugal Pumps

6.1 General.

6.1.1* Types.

6.1.1.1 Centrifugal pumps shall be of the overhung impeller design and the impeller between bearings design.

6.1.1.2 The overhung impeller design shall be close coupled or separately coupled single- or two-stage end-suction-type [see Figure A.6.1.1(a) and Figure A.6.1.1(b)] or in-line-type [see Figure A.6.1.1(c) through Figure A.6.1.1(e)] pumps.

6.1.1.3 The impeller between bearings design shall be separately coupled single-stage or multistage axial (horizontal) split-case-type [see Figure A.6.1.1(f)] or radial (vertical) split-case-type [see Figure A.6.1.1(g)] pumps.

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

6.2* Factory and Field Performance.

6.2.1 Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head.

6.2.2 The shutoff head shall not exceed 140 percent of rated head for any type pump. (See Figure A.6.2.)

6.3 Fittings.

6.3.1* Where necessary, the following fittings for the pump shall be provided by the pump manufacturer or an authorized representative:

- (1) Automatic air release valve
- (2) Circulation relief valve
- (3) Pressure gauges

6.3.2 Where necessary, the following fittings shall be provided:

- (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

6.3.3 Automatic Air Release.

6.3.3.1 Unless the requirements of 6.3.3.2 are met, pumps that are automatically controlled shall be provided with a listed float-operated air release valve having a nominal 0.50 in. (12.7 mm) minimum diameter discharged to atmosphere.

6.3.3.2 The requirements of 6.3.3.1 shall not apply to overhung impeller-type pumps with top centerline discharge or that are vertically mounted to naturally vent the air.



6.4 Foundation and Setting.

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

6.4.2 Pumps of the overhung impeller close coupled in-line type [see Figure A.6.1.1(c)] shall be permitted to be mounted on a base attached to the pump mounting base plate.

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

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

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

6.5* Connection to Driver and Alignment.

6.5.1 Coupling Type.

6.5.1.1 Separately coupled-type pumps with electric motor drivers shall be connected by a flexible coupling or flexible connecting shaft.

6.5.1.2 All coupling types shall be listed for the service referenced in 6.5.1.1.

6.5.2 Pumps and drivers on separately coupled-type pumps shall be aligned in accordance with the coupling and pump manufacturers' specifications and the *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. (See A.6.5.)

Chapter 7 Vertical Shaft Turbine-Type Pumps

7.1* General.

7.1.1* 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.

7.1.2 Characteristics.

7.1.2.1 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.

7.1.2.2 The total shutoff head shall not exceed 140 percent of the total rated head on vertical turbine pumps. (See Figure A.6.2.)

7.2 Water Supply.

7.2.1 Source.

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

7.2.1.2* 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.

7.2.2 Pump Submergence.

7.2.2.1* Well Installations.

7.2.2.1.1 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 (3.2 m) below the pumping water level at 150 percent of rated capacity. (See Figure A.7.2.2.1.)

7.2.2.1.2* The submergence shall be increased by 1 ft (0.3 m) for each 1000 ft (305 m) of elevation above sea level.

7.2.2.2* Wet Pit Installations.

7.2.2.2.1 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.

7.2.2.2.2 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.

7.2.2.2.3 The required submergence shall be obtained from the pump manufacturer.

7.2.2.2.4 The distance between the bottom of the strainer and the bottom of the wet pit shall be at least one-half of the pump bowl diameter but not less than 12 in. (305 mm).

7.2.3 Well Construction.

7.2.3.1 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.

7.2.3.2 The vertical turbine-type pump is designed to operate in a vertical position with all parts in correct alignment.

7.2.3.3 To support the requirements of 7.2.3.1, the well shall be of ample diameter and sufficiently plumb to receive the pump.

7.2.4 Unconsolidated Formations (Sands and Gravels).

7.2.4.1 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.

7.2.4.2 Both inner and outer casings shall have a minimum wall thickness of 0.375 in. (9.5 mm).

7.2.4.3 Inner casing diameter shall be not less than 2 in. (51 mm) larger than the pump bowls.

7.2.4.4 The outer casing shall extend down to approximately the top of the water-bearing formation.

7.2.4.5 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.

7.2.4.6 The well screen is a vital part of the construction, and careful attention shall be given to its selection.

7.2.4.7 The well screen 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).

7.2.4.8 The screen shall be made of a corrosion- and acid-resistant material, such as stainless steel or Monel.

7.2.4.9 Monel shall be used where it is anticipated that the chloride content of the well water will exceed 1000 parts per million.

7.2.4.10 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.

7.2.4.11 The bottom of the well screen shall be sealed properly with a plate of the same material as the screen.

7.2.4.12 The sides of the outer casing shall be sealed by the introduction of neat cement placed under pressure from the bottom to the top.

7.2.4.13 Cement shall be allowed to set for a minimum of 48 hours before drilling operations are continued.

7.2.4.14 The immediate area surrounding the well screen not less than 6 in. (152 mm) shall be filled with clean and well-rounded gravel.

7.2.4.15 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.

7.2.4.16 Tubular Wells.

7.2.4.16.1 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).

7.2.4.16.2 Tubular wells shall comply with all the requirements of 7.2.3 and 7.2.4, except compliance with 7.2.4.11 through 7.2.4.15 shall not be required.

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

7.2.6 Developing a Well.

7.2.6.1 Developing a new well and cleaning it of sand or rock particles (not to exceed 5 ppm) shall be the responsibility of the groundwater supply contractor.

7.2.6.2 Such development shall be performed with a test pump and not a fire pump.

7.2.6.3 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.

7.2.7* Test and Inspection of Well.

7.2.7.1 A test to determine the water production of the well shall be made.

7.2.7.2 An acceptable water measuring device such as an orifice, a venturi meter, or a calibrated pitot tube shall be used.

7.2.7.3 The test shall be witnessed by a representative of the customer, contractor, and authority having jurisdiction, as required.

7.2.7.4 The test 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.

7.2.7.5 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.

7.2.7.6 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.

7.2.7.7 All existing wells within a 1000 ft (305 m) radius of the fire well shall be monitored throughout the test period.

7.3 Pump.

7.3.1* Vertical Turbine Pump Head Component.

7.3.1.1 The pump head shall be either the aboveground or belowground discharge type.

7.3.1.2 The pump head shall be designed to support the driver, pump, column assembly, bowl assembly, maximum down thrust, and the oil tube tension nut or packing container.

7.3.2 Column.

7.3.2.1* 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 7.3.2.1(a) and Table 7.3.2.1(b), and shall be connected by threaded-sleeve couplings or flanges.

Table 7.3.2.1(a) Pump Column Pipe Weights (U.S. Customary)

Nominal Size (in.)	Outside Diameter (O.D.) (in.)	Weight per Unit Length (Plain Ends) (lb/ft)
6	6.625	18.97
7	7.625	22.26
8	8.625	24.70
9	9.625	28.33
10	10.75	31.20
12	12.75	43.77
14	14.00	53.57

Table 7.3.2.1(b) Pump Column Pipe Weights (Metric)

Nominal Size (mm)	Outside Diameter (O.D.) (mm)	Weight per Unit Length (Plain Ends) (kg/m)
150	161	28.230
200	212	36.758
250	264	46.431
300	315	65.137
350	360	81.209

7.3.2.2 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.

7.3.2.3 All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment.

7.3.2.4 Where the static water level exceeds 50 ft (15.3 m) below ground, oil-lubricated-type pumps shall be used. (See Figure A.7.1.1.)

7.3.2.5 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.

7.3.2.6 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.7.1.1.)



7.3.2.7 The pump line shafting shall be sized so critical speed shall be 25 percent above and below the operating speed of the pump.

7.3.2.8 Operating speed shall include all speeds from shutoff to the 150 percent point of the pump, which vary on engine drives.

7.3.2.9 Operating speed for variable speed pressure limiting control drive systems shall include all speeds from rated to minimum operating speed.

7.3.3 Bowl Assembly.

7.3.3.1 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.

7.3.3.2 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.

7.3.4 Suction Strainer.

7.3.4.1 A cast or heavy fabricated, corrosion-resistant metal cone or basket-type strainer shall be attached to the suction manifold of the pump.

7.3.4.2 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 0.5 in. (12.7 mm) sphere.

7.3.4.3 For installations in a wet pit, this suction strainer shall be required in addition to the intake screen. (*See Figure A.7.2.2.2.*)

7.3.5 Fittings.

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

- (1) Automatic air release valve as specified in 7.3.5.2
- (2) Water level detector as specified in 7.3.5.3
- (3) Discharge pressure gauge as specified in 4.10.1
- (4) Relief valve and discharge cone where required by 4.18.1
- (5) Hose valve header and hose valves as specified in 4.20.3 or metering devices as specified in 4.20.2

7.3.5.2 Automatic Air Release.

7.3.5.2.1 A nominal 1.5 in. (38 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.

7.3.5.2.2 This valve shall also admit air to the column to dissipate the vacuum upon stopping of the pump.

7.3.5.2.3 This valve shall be located at the highest point in the discharge line between the fire pump and the discharge check valve.

7.3.5.3* Water Level Detection. Water level detection shall be required for all vertical turbine pumps installed in wells to monitor the suction pressure available at the shutoff, 100 percent flow, and 150 percent flow points, to determine if the pump is operating within its design conditions.

7.3.5.3.1 Each well installation shall be equipped with a suitable water level detector.

7.3.5.3.2 If an air line is used, it shall be brass, copper, or series 300 stainless steel.

7.3.5.3.3 Air lines shall be strapped to column pipe at 10 ft (3 m) intervals.

7.4* Installation.

7.4.1 Pump House.

7.4.1.1 The pump house shall be of such design as will offer the least obstruction to the convenient handling and hoisting of vertical pump parts.

7.4.1.2 The requirements of Sections 4.12 and 11.3 shall also apply.

7.4.2 Outdoor Setting.

7.4.2.1 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.

7.4.2.2 The screen or enclosure required in 7.4.2.1 shall be easily removable and shall have provision for ample ventilation.

7.4.3 Foundation.

7.4.3.1 Certified dimension prints shall be obtained from the manufacturer.

7.4.3.2 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.

7.4.3.3 Foundation bolts shall be provided to firmly anchor the pump to the foundation.

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

7.4.3.5 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.

7.4.3.6 On a well pump, the pump head shall be positioned plumb over the well, which is not necessarily level.

7.4.3.7 Sump or Pit.

7.4.3.7.1 Where the pump is mounted over a sump or pit, I-beams shall be permitted to be used.

7.4.3.7.2 Where a right-angle gear is used, the driver shall be installed parallel to the beams.

7.5 Driver.

7.5.1 Method of Drive.

7.5.1.1 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.

7.5.1.2 All drivers shall be so constructed that axial adjustment of impellers can be made to permit proper installation and operation of the equipment.

7.5.1.3 Vertical shaft turbine pumps shall be driven by a vertical hollow shaft electric motor or vertical hollow shaft right-angle gear drive with diesel engine or steam turbine except as permitted in 7.5.1.4.

7.5.1.4 The requirements of 7.5.1.3 shall not apply to diesel engines and steam turbines designed and listed for vertical installation with vertical shaft turbine-type pumps, which shall be permitted to employ solid shafts and shall not require a right-angle gear drive but shall require a nonreverse ratchet.

7.5.1.5 Motors shall be of the vertical hollow-shaft type and comply with 9.5.1.9.

7.5.1.6 Mass Elastic System.

7.5.1.6.1 For drive systems that include a right angle gear drive, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump and drive.

7.5.1.6.2 The torsional analysis specified in 7.5.1.6.1 shall include the mass elastic characteristics for a wetted pump with the specific impeller trim, coupling, right-angle gear, flexible connecting shaft, and engine, plus the excitation characteristics of the engine.

7.5.1.6.3 For variable speed vertical hollow shaft electric motors, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump and drive.

7.5.1.7 Gear Drives.

7.5.1.7.1 Gear drives and flexible connecting shafts shall be acceptable to the authority having jurisdiction.

7.5.1.7.2 Gear drives shall be of the vertical hollow-shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment.

7.5.1.7.3 The gear drive shall be equipped with a nonreverse ratchet.

7.5.1.7.4 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.

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

7.5.1.8 Flexible Connecting Shafts.

7.5.1.8.1 The flexible connecting shaft shall be listed for this service.

7.5.1.8.2 The operating angle for the flexible connecting shaft shall not exceed the limits specified by the manufacturer for the speed and horsepower transmitted under any static or operating conditions.

7.5.2 Controls. The controllers for the motor, diesel engine, or steam turbine shall comply with specifications for either electric-drive controllers in Chapter 10 or engine drive controllers in Chapter 12.

7.5.3 Variable Speed Vertical Turbine Pumps.

7.5.3.1 The pump supplier shall inform the controller manufacturer of any and all critical resonant speeds within the operating speed range of the pump, which is from zero up to full speed.

7.5.3.2 When water-lubricated pumps with line shaft bearings are installed, the pump manufacturer shall inform the controller manufacturer of the maximum allowed time for water to reach the top bearing under the condition of the lowest anticipated water level of the well or reservoir.

7.6 Operation and Maintenance.

7.6.1 Operation.

7.6.1.1* 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.

7.6.1.2 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.

7.6.1.3 With the top drive coupling reinstalled, the impellers shall be set for proper clearance according to the manufacturer's instructions.

7.6.1.4* With the precautions of 7.6.1.1 through 7.6.1.3 taken, the pump shall be started and allowed to run.

7.6.1.5 The operation shall be observed for vibration while running, with vibration limits according to the *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*.

7.6.1.6 The driver shall be observed for proper operation.

7.6.2 Maintenance.

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

7.6.2.2 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.

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

Chapter 8 Positive Displacement Pumps

8.1* General.

8.1.1 Types. Positive displacement pumps shall be as defined in 3.3.37.13.

8.1.2* Suitability.

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

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

8.1.3 Application.

8.1.3.1 Positive displacement pumps shall be permitted to pump liquids for fire protection applications.

8.1.3.2 The selected pump shall be appropriate for the viscosity of the liquid.

8.1.4 Pump Seals.

8.1.4.1 The seal type acceptable for positive displacement pumps shall be either mechanical or lip seal.

8.1.4.2 Packing shall not be used.

8.1.5* Pump Materials. Materials used in pump construction shall be selected based on the corrosion potential of the environment, fluids used, and operational conditions. (*See 3.3.9 for corrosion-resistant materials.*)

8.1.6 Dump Valve.

8.1.6.1 A dump valve shall be provided on all closed head systems to allow the positive displacement pump to bleed off excess pressure and achieve operating speed before subjecting the driver to full load.



8.1.6.2 The dump valve shall operate only for the duration necessary for the positive displacement pump to achieve operating speed.

8.1.6.3 Dump Valve Control.

8.1.6.3.1 Automatic Operation. When an electrically operated dump valve is used, it shall be controlled by the positive displacement pump controller.

8.1.6.3.2 Manual Operation. Means shall be provided at the controller to ensure dump valve operation during manual start.

8.1.6.4 Dump valves shall be listed.

8.1.6.5 Dump valve discharge shall be permitted to be piped to the liquid supply tank, pump suction, drain, or liquid supply.

8.2 Foam Concentrate and Additive Pumps.

8.2.1 Additive Pumps. Additive pumps shall meet the requirements for foam concentrate pumps.

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

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

8.2.4* Dry Run. Foam concentrate pumps shall be capable of dry running for 10 minutes without damage.

8.2.5* Minimum Flow Rates. Pumps shall have foam concentrate flow rates to meet the maximum foam flow demand for their intended service.

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

8.3 Water Mist System Pumps.

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

8.3.2 NPSH shall exceed the pump manufacturer's required NPSH plus 5 ft (1.52 m) of liquid.

8.3.3 The inlet pressure to the pump shall not exceed the pump manufacturer's recommended maximum inlet pressure.

8.3.4 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.

8.3.5 Where the pump is equipped with an unloader valve, it shall be in addition to the safety relief valve as outlined in 8.4.2.

8.4 Fittings.

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

8.4.2* General Information for Relief Valves.

8.4.2.1 All pumps shall be equipped with a listed safety relief valve capable of relieving 100 percent of the rated pump capacity at a pressure not exceeding 125 percent of the relief valve set pressure.

8.4.2.2 The pressure relief valve shall be set such that the pressure required to discharge the rated pump capacity is at or below the lowest rated pressure of any component.

8.4.2.3 The relief valve shall be installed on the pump discharge to prevent damage to the fire protection system.

8.4.3* Relief Valves for Foam Concentrate Pumps. For foam concentrate pumps, safety relief valves shall be piped to return the valve discharge to the concentrate supply tank.

8.4.4* Relief Valves for Water Mist Pumps.

8.4.4.1 For positive displacement water mist pumps, safety relief valves shall discharge to a drain or to a water supply at atmospheric pressure.

8.4.4.2 A means of preventing overheating shall be provided when the relief valve is plumbed to discharge to the pump suction.

8.4.5* Suction Strainer.

8.4.5.1 Pumps shall be equipped with a removable and cleanable suction strainer installed at least 10 pipe diameters from the pump suction inlet.

8.4.5.2 Suction strainer pressure drop shall be calculated to ensure that sufficient NPSH is available to the pump.

8.4.5.3 The net open area of the strainer shall be at least four times the area of the suction piping.

8.4.5.4 Strainer mesh size shall be in accordance with the pump manufacturer's recommendation.

8.4.6 Water Supply Protection. Design of the system shall include protection of potable water supplies and prevention of cross connection or contamination.

8.5 Pump Drivers.

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

8.5.2 Reduction Gears.

8.5.2.1 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*.

8.5.2.2 Gears shall be AGMA Class 7 or better, and pinions shall be AGMA Class 8 or better.

8.5.2.3 Bearings shall be in accordance with AGMA standards and applied for an L10 life of 15,000 hours.

8.5.2.4 For drive systems that include a gear case, the pump manufacturer shall provide a complete mass elastic system torsional analysis to ensure there are no damaging stresses or critical speeds within 25 percent above and below the operating speed of the pump(s) and driver.

8.5.2.4.1 For variable speed drives, the analysis of 8.5.2.4 shall include all speeds down to 25 percent below the lowest operating speed obtainable with the variable speed drive.

8.5.3 Common Drivers.

8.5.3.1 A single driver shall be permitted to drive more than one positive displacement pump.

8.5.3.2 Redundant pump systems shall not be permitted to share a common driver.

8.6* Controllers. See Chapters 10 and 12 for requirements for controllers.

8.7 Foundation and Setting.

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

8.7.2 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.

8.7.3 The foundation shall provide a solid support for the base plate.

8.8 Driver Connection and Alignment.

8.8.1 The pump and driver shall be connected by a listed, closed coupled, flexible coupling or timing gear type of belt drive coupling.

8.8.2 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 operating speed.

8.8.3 Pumps and drivers shall be aligned once final base plate placement is complete.

8.8.4 Alignment shall be in accordance with the coupling manufacturer's specifications.

8.8.5 The operating angle for the flexible coupling shall not exceed the recommended tolerances.

8.9 Flow Test Devices.

8.9.1 A positive displacement 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 pump.

8.9.2 Additive pumping systems shall be equipped with a flow meter or orifice plate installed in a test loop back to the additive supply tank.

8.9.3 Water pumping systems shall be equipped with a flow-meter or orifice plate installed in a test loop back to the water supply, tank, inlet side of the water pump, or drain.

Chapter 9 Electric Drive for Pumps

9.1 General.

9.1.1 This chapter covers the minimum performance and testing requirements of the sources and transmission of electrical power to motors driving fire pumps.

9.1.2 This chapter also covers the minimum performance requirements of all intermediate equipment between the source(s) and the pump, including the motor(s) but excluding the electric fire pump controller, transfer switch, and accessories (*see Chapter 10*).

9.1.3 All electrical equipment and installation methods shall comply with *NFPA 70, National Electrical Code*, Article 695, and other applicable articles.

9.1.4* All power supplies shall be located and arranged to protect against damage by fire from within the premises and exposing hazards.

9.1.5 All power supplies shall have the capacity to run the fire pump on a continuous basis.

9.1.6 All power supplies shall comply with the voltage drop requirements of Section 9.4.

9.1.7* Phase converters shall not be used to supply power to a fire pump.

9.2 Normal Power.

9.2.1 An electric motor-driven fire pump shall be provided with a normal source of power as a continually available source.

9.2.2 The normal source of power required in 9.2.1 and its routing shall be arranged in accordance with one of the following:

- (1) Service connection dedicated to the fire pump installation
- (2) On-site power production facility connection dedicated to the fire pump installation
- (3) Dedicated feeder connection derived directly from the dedicated service to the fire pump installation
- (4) As a feeder connection where all of the following conditions are met:
 - (a) The protected facility is part of a multibuilding campus-style arrangement.
 - (b) A backup source of power is provided from a source independent of the normal source of power.
 - (c) It is impractical to supply the normal source of power through the arrangement in 9.2.2(1), 9.2.2(2), or 9.2.2(3).
 - (d) The arrangement is acceptable to the authority having jurisdiction.
 - (e) The overcurrent protection device(s) in each disconnecting means is selectively coordinated with any other supply side overcurrent protective device(s).
- (5) Dedicated transformer connection directly from the service meeting the requirements of Article 695 of *NFPA 70, National Electrical Code*

9.2.3 For fire pump installations using the arrangement of 9.2.2(1), 9.2.2(2), 9.2.2(3), or 9.2.2(5) for the normal source of power, no more than one disconnecting means and associated overcurrent protection device shall be installed in the power supply to the fire pump controller.

9.2.3.1 Where the disconnecting means permitted by 9.2.3 is installed, the disconnecting means shall meet all of the following:

- (1) They shall be identified as being suitable for use as service equipment.
- (2) They shall be lockable in the closed position.
- (3)*They shall be located remote from other building disconnecting means.
- (4)*They shall be located remote from other fire pump source disconnecting means.
- (5) They shall be marked "Fire Pump Disconnecting Means" in letters that are no less than 1 in. (25 mm) in height and that can be seen without opening enclosure doors or covers.

9.2.3.2 Where the disconnecting means permitted by 9.2.3 is installed, a placard shall be placed adjacent to the fire pump controller stating the location of this disconnecting means and the location of any key needed to unlock the disconnect.

9.2.3.3 Where the disconnecting means permitted by 9.2.3 is installed, the disconnect 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 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



9.2.3.4 Where the overcurrent protection permitted by 9.2.3 is installed, the overcurrent protection device shall be rated to carry indefinitely the sum of the locked rotor current of the fire pump motor(s) and the pressure maintenance pump motor(s) and the full-load current of the associated fire pump accessory equipment.

9.3 Alternate Power.

9.3.1 Except for an arrangement described in 9.3.3, at least one alternate source of power shall be provided where the height of the structure is beyond the pumping capacity of the fire department apparatus.

9.3.2* Other Sources. Except for an arrangement described in 9.3.3, at least one alternate source of power shall be provided where the normal source is not reliable.

9.3.3 An alternate source of power is not required where a backup engine-driven or backup steam turbine-driven fire pump is installed in accordance with this standard.

9.3.4 Where provided, the alternate source of power shall be supplied from one of the following sources:

- (1) A generator installed in accordance with Section 9.6
- (2) One of the sources identified in 9.2.2(1), 9.2.2(2), 9.2.2(3), or 9.2.2(5) where the power is provided independent of the normal source of power

9.3.5 Where provided, the alternate supply shall be arranged so that the power to the fire pump is not disrupted when overhead lines are de-energized for fire department operations.

9.3.6 Two or More Alternate Sources. Where the alternate source consists of two or more sources of power and one of the sources is a dedicated feeder derived from a utility service separate from that used by the normal source, the disconnecting means, overcurrent protective device, and conductors shall not be required to meet the requirements of Section 9.2 and shall be permitted to be installed in accordance with *NFPA 70, National Electrical Code*.

9.4* Voltage Drop.

9.4.1 Unless the requirements of 9.4.2 or 9.4.3 are met, the voltage at the controller line terminals shall not drop more than 15 percent below normal (controller-rated voltage) under motor-starting conditions.

9.4.2 The requirements of 9.4.1 shall not apply to emergency-run mechanical starting. (See 10.5.3.2.)

9.4.3 The requirements of 9.4.1 shall not apply to the bypass mode of a variable speed pressure limiting control (see 10.10.3), provided a successful start can be demonstrated on the standby gen-set.

9.4.4 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.

9.5 Motors.

9.5.1 General.

9.5.1.1 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 9.5.1.1.)

Table 9.5.1.1 Horsepower and Locked Rotor Current Motor Designation for NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 460 V (A)	Motor Designation (NFPA 70, Locked Rotor Indicating Code Letter) "F" to and Including
5	46	J
7½	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

9.5.1.2 The requirements of 9.5.1.1 shall not apply to direct-current, high-voltage (over 600 V), large-horsepower [over 500 hp (373 kW)], single-phase, universal-type, or wound-rotor motors, which shall be permitted to be used where approved.

9.5.1.3 Part-winding motors shall have a 50-50 winding ratio in order to have equal currents in both windings while running at nominal speed.

9.5.1.4 Motors used with variable speed controllers shall additionally meet the applicable requirements of NEMAMG-1, *Motors and Generators*, Part 31 and shall be marked for inverter duty.

9.5.1.5* 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 9.5.1.1.

9.5.1.6 Code letters of motors for all other voltages shall conform with those shown for 460 V in Table 9.5.1.1.

9.5.1.7 All motors shall be rated for continuous duty.

9.5.1.8 Electric motor-induced transients shall be coordinated with the provisions of 10.4.3.3 to prevent nuisance tripping of motor controller protective devices.

9.5.1.9 Motors for Vertical Shaft Turbine-Type Pumps.

9.5.1.9.1 Motors for vertical shaft turbine-type pumps shall be drip-proof, squirrel-cage induction type.

9.5.1.9.2 The motor shall be equipped with a nonreverse ratchet.

9.5.2 Current Limits.

9.5.2.1 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.

9.5.2.2 The following shall apply to the service factor:

- (1) The maximum service factor at which a motor shall be used is 1.15.
- (2) Where the motor is used with a variable speed pressure limiting controller, the service factor shall not be used.

9.5.2.3 These service factors shall be in accordance with NEMA MG-1, *Motors and Generators*.

9.5.2.4 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.

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

9.5.3 Marking.

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

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

9.6 On-Site Standby Generator Systems.

9.6.1 Capacity.

9.6.1.1 Where on-site generator systems are used to supply power to fire pump motors to meet the requirements of 9.3.2, 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) while meeting the requirements of Section 9.4.

9.6.1.2 A tap ahead of the on-site generator disconnecting means shall not be required.

9.6.2* Power Sources.

9.6.2.1 On-site standby generator systems shall comply with Section 9.4 and shall meet the requirements of Level 1, Type 10, Class X systems of NFPA 110, *Standard for Emergency and Standby Power Systems*.

9.6.2.2 The engine shall run and continue to produce rated nameplate power without shutdown or de-rate for alarms and warnings, or failed engine sensors, except for overspeed shutdown.

9.6.2.3 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.

9.6.3 Sequencing. Automatic sequencing of the fire pumps shall be permitted in accordance with 10.5.2.5.

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

9.6.5* Protective Devices. Protective devices installed in the on-site power source circuits at the generator shall allow instantaneous pickup of the full pump room load and shall comply with NFPA 70, *National Electrical Code*, Section 700.27.

9.7 Junction Boxes. Where fire pump wiring to or from a fire pump controller is routed through a junction box, the following requirements shall be met:

- (1) The junction box shall be securely mounted.
- (2)*Mounting and installation of a junction box shall not violate the enclosure type rating of the fire pump controller(s).
- (3)*Mounting and installation of a junction box shall not violate the integrity of the fire pump controller(s) and shall not affect the short circuit rating of the controller(s).
- (4) As a minimum, a Type 2, dripproof enclosure (junction box) shall be used. The enclosure shall be listed to match the fire pump controller enclosure type rating.
- (5) Terminals, junction blocks, and splices, where used, shall be listed.

9.8 Listed Electrical Circuit Protective System to Controller Wiring.

9.8.1* Where single conductors (individual conductors) are used, they shall be terminated in a separate junction box. Single conductors (individual conductors) shall not enter the fire pump enclosure separately.

9.8.2* The raceway between a junction box and the fire pump controller shall be sealed at the junction box end with an identified compound and in accordance with the instructions of the electrical circuit protective systems if provided.

9.8.3 Standard wiring between the junction box and the controller is acceptable.

9.9 Raceway Terminations.

9.9.1 Listed conduit hubs shall be used to terminate raceway (conduit) to the fire pump controller.

9.9.2 The type rating of the conduit hub(s) shall be at least equal to that of the fire pump controller.

9.9.3 The installation instructions of the manufacturer of the fire pump controller shall be followed.

9.9.4 Alterations to the fire pump controller, other than conduit entry as allowed by NFPA 70, *National Electrical Code*, shall be approved by the authority having jurisdiction.

Chapter 10 Electric-Drive Controllers and Accessories

10.1 General.

10.1.1 Application.

10.1.1.1 This chapter covers the minimum performance and testing requirements for controllers and transfer switches for electric motors driving fire pumps.

10.1.1.2 Accessory devices, including fire pump alarm and signaling means, are included where necessary to ensure the minimum performance of the equipment mentioned in 10.1.1.1.

10.1.2 Performance and Testing.

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

10.1.2.2* Marking.

10.1.2.2.1 The controller and transfer switch shall be suitable for the available short-circuit current at the line terminals of the controller and transfer switch.



10.1.2.2.2 The controller and transfer switch shall be marked "Suitable for use on a circuit capable of delivering not more than ____ amperes RMS symmetrical at ____ volts ac," or "____ amperes RMS symmetrical at ____ volts ac short-circuit current rating," or equivalent, where the blank spaces shown shall have appropriate values filled in for each installation.

10.1.2.3 Preshipment. All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory. Controllers shipped in sections shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory. Such controllers shall be reassembled in the field, and the proper assembly shall be verified by the manufacturer or designated representative.

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

10.1.2.5 Additional Marking.

10.1.2.5.1 All controllers shall be marked "Electric Fire Pump Controller" and shall show plainly the name of the manufacturer, identifying designation, maximum operating pressure, enclosure type designation, and complete electrical rating.

10.1.2.5.2 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.

10.1.2.6 Service Arrangements. 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.

10.1.2.7 State of Readiness. The controller shall be in a fully functional state within 10 seconds upon application of ac power.

10.1.3* Design. All electrical control equipment design shall comply with *NFPA 70, National Electrical Code*, Article 695, and other applicable documents.

10.2 Location.

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

10.2.2 Controllers shall be located or protected so that they will not be damaged by water escaping from pumps or pump connections.

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

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

10.3 Construction.

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

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

10.3.3 Enclosures.

10.3.3.1* The structure or panel shall be securely mounted in, as a minimum, a National Electrical Manufacturers Association (NEMA) Type 2, dripproof enclosure(s) or an enclosure(s) with an ingress protection (IP) rating of IP31.

10.3.3.2 Where the equipment is located outside, or where special environments exist, suitably rated enclosures shall be used.

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

10.3.4 Connections and Wiring.

10.3.4.1 All busbars and connections shall be readily accessible for maintenance work after installation of the controller.

10.3.4.2 All busbars and connections shall be arranged so that disconnection of the external circuit conductors will not be required.

10.3.4.3 Means shall be provided on the exterior of the controller to read all line currents and all line voltages with an accuracy within ± 5 percent of motor nameplate voltage and current.

10.3.4.4 Continuous-Duty Basis.

10.3.4.4.1 Unless the requirements of 10.3.4.4.2 are met, busbars and other wiring elements of the controller shall be designed on a continuous-duty basis.

10.3.4.4.2 The requirements of 10.3.4.4.1 shall not apply to conductors that are in a circuit only during the motor starting period, which shall be permitted to be designed accordingly.

10.3.4.5 Field Connections.

10.3.4.5.1 A fire pump controller shall not be used as a junction box to supply other equipment.

10.3.4.5.2 No undervoltage, phase loss, frequency sensitive, or other device(s) shall be field installed that automatically or manually prohibits electrical actuation of the motor contactor.

10.3.4.6 Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the fire pump controller.

10.3.5 Protection of Control Circuits.

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

10.3.5.2 The secondary of the transformer and control circuitry shall be permitted to be ungrounded except as required in 10.6.5.4.

10.3.6* External Operation. All switching equipment for manual use in connecting or disconnecting or starting or stopping the motor shall be externally operable.

10.3.7 Electrical Diagrams and Instructions.

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

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

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

10.3.8 Marking.

10.3.8.1 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.

10.3.8.2 The markings shall be so located as to be visible after installation.

10.4 Components.

10.4.1* Voltage Surge Arrester.

10.4.1.1 Unless the requirements of 10.4.1.3 or 10.4.1.4 are met, a voltage surge arrester complying with ANSI/IEEE C62.1, *IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits*, or ANSI/IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV)*, shall be installed from each phase to ground. (See 10.3.3.3.)

10.4.1.2 The surge arrester shall be rated to suppress voltage surges above line voltage.

10.4.1.3 The requirements of 10.4.1.1 and 10.4.1.2 shall not apply to controllers rated in excess of 600 V. (See Section 10.6.)

10.4.1.4 The requirements of 10.4.1.1 and 10.4.1.2 shall not apply where the controller can withstand without damage a 10 kV impulse in accordance with ANSI/IEEE C62.41, *IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits*.

10.4.2 Isolating Switch.

10.4.2.1 General.

10.4.2.1.1 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.

10.4.2.1.2* 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.

10.4.2.1.3 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.

10.4.2.2 Externally Operable. The isolating switch shall be externally operable.

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

10.4.2.4 Warning.

10.4.2.4.1 Unless the requirements of 10.4.2.4.2 are met, the following warning shall appear on or immediately adjacent to the isolating switch:

WARNING

**DO NOT OPEN OR CLOSE THIS SWITCH WHILE
THE CIRCUIT BREAKER (DISCONNECTING MEANS)
IS IN CLOSED POSITION.**

10.4.2.4.2 Instruction Label. The requirements of 10.4.2.4.1 shall not apply where the requirements of 10.4.2.4.2.1 and 10.4.2.4.2.2 are met.

10.4.2.4.2.1 Where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither 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.

10.4.2.4.2.2 This label shall be permitted to be part of the label required by 10.3.7.3.

10.4.2.5 Operating Handle.

10.4.2.5.1 Unless the requirements of 10.4.2.5.2 are met, 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.

10.4.2.5.2 The requirements of 10.4.2.5.1 shall not apply where the isolating switch and the circuit breaker are so interlocked that the isolating switch can be neither opened nor closed while the circuit breaker is closed.

10.4.3 Circuit Breaker (Disconnecting Means).

10.4.3.1* General. 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.

10.4.3.2 Mechanical Characteristics. The circuit breaker shall have the following mechanical characteristics:

- (1) It shall be externally operable. (See 10.3.6.)
- (2) It shall trip free of the handle.
- (3) A nameplate with the legend “Circuit breaker — disconnecting means” in letters not less than $\frac{3}{8}$ in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for operating the circuit breaker.

10.4.3.3* Electrical Characteristics.

10.4.3.3.1 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 10.1.2.2 of the controller
- (5) Capability of allowing normal and emergency starting and running of the motor without tripping (see 10.5.3.2)
- (6) An instantaneous trip setting of not more than 20 times the full-load current

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

- (1) The breaker shall accept current limiters of only one rating.
- (2) The current limiters shall hold 300 percent of full-load motor current for a minimum of 30 minutes.
- (3) The current limiters, where installed in the breaker, shall not open at locked rotor current.
- (4) A spare set of current limiters of correct rating shall be kept readily available in a compartment or rack within the controller enclosure.

10.4.4 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:

- (1) For a squirrel-cage or wound-rotor induction motor, the device shall be as follows:
 - (a) Of the time-delay type having a tripping time between 8 seconds and 20 seconds at locked rotor current
 - (b) Calibrated and set at a minimum of 300 percent of motor full-load current

