

NFPA[®]

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**Standard for the
Installation of
Stationary Pumps
for Fire Protection**

2022



NFPA® 20

Standard for the Installation of Stationary Pumps for Fire Protection

2022 Edition



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NFPA® 20

Standard for the

Installation of Stationary Pumps for Fire Protection

2022 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. It was issued by the Standards Council on March 18, 2021, with an effective date of April 8, 2021, and supersedes all previous editions.

This edition of NFPA 20 was approved as an American National Standard on April 8, 2021.

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 included 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 was reorganized.

The 2013 edition clarified and added new requirements for water mist positive displacement pumping units. Chapter 5 of the standard was reorganized. Limited service controller requirements were revised, and the component replacement table was removed.

The 2016 edition of NFPA 20 provided new requirements for pumps in series relative to protection of control wiring, status signals, and communications. NFPA 20 recognized the potential use of multistage, multiport pumps in fire suppression systems and provided requirements specific to that application. Break tank criteria were removed and are now in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*. A new annex, Annex C, was added to provide guidance on controller security where a controller is connected to the Internet. New requirements were added to address use of an automatic fuel maintenance system with a diesel fire pump installation. In addition, protection criteria for both a diesel fire pump room and an electric fire pump room were defined in Chapter 4.

The 2019 edition of NFPA 20 was revised to recognize new technologies, including automated inspection and testing, distance monitoring, automated valves, and self-regulating variable speed fire pump units. Provisions were added to require that a single entity be responsible for acceptable fire pump unit performance. A new definition for *lowest permissible suction pressure* was added to provide a better understanding of the maximum available flow by connecting it to a suction pressure. Requirements were added to clarify where manifolding of fire pump test piping is permitted, as well as where combining fire pump test piping with relief valve discharge piping is permitted. New definitions were added to differentiate between *standby power* and *alternate power* and to ensure proper application of these terms throughout the document. The term *very tall building* was defined and the requirements pertaining to these buildings expanded, including those for automatic tank refill valves. New requirements and annex material were added to help package designers through the evaluation of mass elastic systems. The requirements for hydraulic cranking systems were revised to distinguish between systems used as primary cranking systems and those used as secondary cranking systems. Annex C was revised significantly to make data formatting more universal.

The 2022 edition incorporates clarifications on a wide array of topics, including pump currents, overcurrent protection devices, transfer switch installation, test header pipe size as well as other pipe size requirements based on number of fittings used. The positive displacement pump requirements have been reorganized and enhanced with the inclusion of new performance requirements. The committee recognized improved fuel consumption of diesel engines and updated fuel supply tank capacity requirements. Other changes include clarification of separate requirements for vertical and horizontal shaft centrifugal pumps, automated inspection listing requirements, minimum water level in storage tanks, clarification on vertical fire protection zones, inclusion of operating and installation instructions, and new requirements for mechanical seals and maximum time allowed to achieve design pressure.

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

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*, 2022 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2021 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 70E®, *Standard for Electrical Safety in the Workplace®*, 2021 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2022 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 2019 edition.

2.3 Other Publications.

2.3.1 AGMA Publications. American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314-1587.

ANSI/AGMA 2011-B14, *Cylindrical Wormgearing Tolerance and Inspection Methods*, 2014.

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

ANSI B11.19, *Performance Requirements for Safeguarding*, 2010.

2.3.3 ASCE Publications. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*, 2016.

2.3.4 ASME Publications. ASME International, Two Park Avenue, New York, NY 10016-5990.

Boiler and Pressure Vessel Code, 2019.

2.3.5 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM SI10, *IEEE/ASTM SI 10 American National Standard for Metric Practice*, 2016.

2.3.6 AWS Publications. American Welding Society, 8669 NW 36 Street, Suite 130, Miami, FL 33166-6672.

AWS D1.1/D1.1M, *Structural Welding Code — Steel*, 2015.

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

ANSI/HI 1.4, *Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation and Maintenance*, 2014.

ANSI/HI 3.6, *Rotary Pump Tests*, 2016.

2.3.8 IEEE Publications. IEEE, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE C62.1, *IEEE Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits*, 1989.

IEEE C62.11, *IEEE Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1 kV)*, 2012.

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

2.3.9 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO 15540, *Fire Resistance of Non-Metallic Hose Assemblies and Non-Metallic Compensators — Test Methods*, 2nd edition, 2016.

2.3.10 NEMA Publications. National Electrical Manufacturers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209.

NEMA MG-1, *Motors and Generators*, 2018.

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

UL 142, *Steel Aboveground Tanks for Flammable and Combustible Liquids*, 2019.

UL 508, *Industrial Control Equipment*, 2018.

UL 1449, *Surge Protective Devices*, 2018.

2.3.12 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*, 2019 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2018 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2019 edition.

NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*, 2018 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2021 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. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

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 Alternate Power. See 3.3.48.1.

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

3.3.4 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.

3.3.5 Automated Inspection and Testing. The performance of inspections and tests at a distance from the system or component being inspected or tested through the use of electronic devices or equipment installed for the purpose.

3.3.6 Automatic. Performing a function without the necessity of human intervention. [70:100]

3.3.7 Automatic Transfer Switch. See 3.3.69.2.1.

3.3.8 Branch Circuit. See 3.3.11.1.

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

3.3.10 Churn. See 3.3.43, No Flow (Churn, Shutoff).

3.3.11 Circuit.

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

3.3.11.2 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.

3.3.12 Circulation Relief Valve. See 3.3.77.4.1.

3.3.13 Corrosion-Resistant Material. Materials such as brass, copper, stainless steel, or other materials that withstand corrosion damage caused by oxidation or other chemical reactions.

3.3.14 Diesel Engine. See 3.3.19.1.

3.3.15 Discharge Pressure. See 3.3.49.1.

3.3.16 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. [70:100]

3.3.17 Distance Monitoring. The monitoring of various conditions of a system or component from a location distant from the system or component through the use of electronic devices, meters, or equipment installed for the purpose.

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

3.3.19 Engine.

3.3.19.1* 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.

3.3.19.1.1 Internal Combustion Engine. Any engine in which the working medium consists of the products of combustion of the air and fuel supplied.

3.3.20 Engine Battery. A battery used to provide sufficient electrical energy to crank the engine to achieve engine start and the necessary energy for system controls.

3.3.21 Fault Tolerant External Control Circuit. See 3.3.11.2.

Δ 3.3.22 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. [70:100]

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

3.3.24 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.

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

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

3.3.27 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.

3.3.28 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.

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

3.3.30* 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.

3.3.30.1 Net Positive Suction Head (NPSH) (h_{sn}). 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.

3.3.30.2 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.

3.3.30.3 Total Head.

3.3.30.3.1* 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.

3.3.30.3.2* 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.

3.3.30.4 Total Rated Head. The total head developed at rated capacity and rated speed for a centrifugal pump.

3.3.30.5 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.

3.3.30.6* Velocity Head (h_v). The kinetic energy of a unit weight of fluid moving with velocity (v) determined at the point of the gauge connection.

3.3.31 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, 2021]

Δ 3.3.32 In Sight From (Within Sight From, Within Sight). Where this Code specifies that one equipment shall be “in sight from,” “within sight from,” or “within sight of,” and so forth, another equipment, the specified equipment is to be visible and not more than 15 m (50 ft) distant from the other. [70:100]

3.3.33 Internal Combustion Engine. See 3.3.19.1.1.

3.3.34 Isolating Switch. See 3.3.69.1.

3.3.35 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.

3.3.36 Liquid Level.

3.3.36.1 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.

3.3.36.2 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.

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

3.3.38 Manual Transfer Switch. See 3.3.69.2.2.

Δ 3.3.39* Maximum Pump Brake Horsepower. The maximum brake horsepower required to drive the pump at rated speed.

3.3.40 Motor.

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

3.3.40.2 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.

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

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

3.3.40.5 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.

3.3.40.6 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.

3.3.40.7 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.

3.3.40.8 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.

3.3.40.9 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.

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

3.3.41 Net Positive Suction Head (NPSH) (h_{sn}). See 3.3.30.1.

3.3.42 Net Pressure (Differential Pressure). See 3.3.49.3.

3.3.43* No Flow (Churn, Shutoff). The condition of zero flow when the fire pump is running but the only water passing through the pump is a small flow that is discharged through the pump circulation relief valve or supplies the cooling for a diesel engine driver.

N 3.3.44 Nonautomatic. Requiring human intervention to perform a function. [70:100]

3.3.45 On-Site Power Production Facility. See 3.3.48.2.

3.3.46* On-Site Standby Generator. See 3.3.48.3.

3.3.47* Peak Load. As it pertains to acceptance testing in this standard, the maximum power required to drive the pump at any flow rate up to 150 percent of rated capacity (flow).

3.3.48 Power.

3.3.48.1 Alternate Power. A power source that is independent of the primary power supply.

3.3.48.2 On-Site Power Production Facility. An on-site normal supply of electric power that is expected to be constantly producing power. [70:695.2]

3.3.48.3 On-Site Standby Generator. A facility producing electric power on site as the alternate supply of electric power. It differs from an on-site power production facility, in that it is not constantly producing power. [70:695.2]

3.3.48.4 Standby Power. An alternate power source that is normally inactive but becomes active whenever the primary power is lost.

3.3.49 Pressure.

3.3.49.1 Discharge Pressure. The total pressure available at the fire pump discharge flange.

3.3.49.2* Lowest Permissible Suction Pressure. The lowest suction pressure permitted by this standard and the authority having jurisdiction.

3.3.49.3* Net Pressure (Differential Pressure). For vertical turbine fire pumps, the total pressure at the fire pump discharge flange plus the total suction lift. For other fire pumps, the total pressure at the fire pump discharge flange minus the total pressure at the fire pump suction flange.

3.3.49.4 Rated Pressure. The net pressure (differential pressure) at rated flow and rated speed as marked on the manufacturer's nameplate.

3.3.49.5 Suction Pressure. The total pressure available at the fire pump suction flange.

3.3.50 Pressure-Regulating Device. A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure. [14, 2019]

3.3.51 Pump.

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

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

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

3.3.51.4 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.

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

3.3.51.6 Foam Concentrate Pump. See 3.3.51.1, Additive Pump.

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

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

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

3.3.51.10 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.

3.3.51.11* Multistage Multiport Pump. A single-driver pump with multiple impellers operating in series where the discharge from each impeller, except the last impeller, is the suction for the next impeller, and discharge ports are provided after multiple impellers.

3.3.51.12 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.

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

3.3.51.14 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.

3.3.51.15 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.

3.3.51.16 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.

3.3.51.17 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.

3.3.51.18 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.

3.3.51.19* Water Mist Positive Displacement Pumping Unit. Multiple positive displacement pumps designed to operate in parallel that discharges into a single common water mist distribution system.

3.3.52 Pumping Liquid Level. See 3.3.36.1.

3.3.53 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, 2018]

3.3.54 Rated Flow. The capacity of the pump at rated speed and rated pressure as marked on the manufacturer's nameplate.

3.3.55 Rated Pressure. See 3.3.49.4.

3.3.56 Record Drawing (As-Built). A design, working drawing, or as-built drawing that is submitted as the final record of documentation for the project.

3.3.57* Series Fire Pump Unit. All fire pump units located within the same building that operate in a series arrangement where the first fire pump takes suction directly from a water supply and each sequential pump takes suction under pump pressure from the preceding pump. Two pumps that operate in series through a tank(s) or break tank(s) are not considered part of a series fire pump unit.

Δ 3.3.58* Service. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served. [70:100]

Δ 3.3.59* 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. [70:100]

3.3.60 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.

3.3.61* Set Pressure. As applied to variable speed pumps, the pressure that the variable speed pressure limiting control system is set to maintain.

3.3.62 Shutoff (No Flow, Churn). See 3.3.43, No Flow (Churn, Shutoff).

3.3.63* Signal. An indicator of status.

3.3.64 Speed.

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

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

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

3.3.65 Standby Power. See 3.3.48.4.

3.3.66 Static Liquid Level. See 3.3.36.2.

3.3.67 Suction Diffuser. A device that provides uniform flow into the suction side of a pump, equivalent to 10 pipe-diameters of straight pipe.

3.3.68 Suction Pressure. See 3.3.49.5.

3.3.69 Switch.

3.3.69.1 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.

3.3.69.2 Transfer Switch.

3.3.69.2.1 Automatic Transfer Switch (ATS). Self-acting equipment for transferring the connected load from one power source to another power source. [110, 2019]

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

3.3.70 Torsional Coupling. A driveline component capable of transmitting torque having a very low spring constant along the axis of rotation to detune the driveline and move any damaging resonances safely below operating speed.

3.3.71 Total Discharge Head (h_d). See 3.3.30.2.

3.3.72 Total Head (H), Horizontal Pumps. See 3.3.30.3.1.

3.3.73 Total Head (H), Vertical Turbine Pumps. See 3.3.30.3.2.

3.3.74 Total Rated Head. See 3.3.30.4.

3.3.75 Total Suction Head (h_s). See 3.3.30.5.

3.3.76 Total Suction Lift (h_s). 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.

3.3.77 Valve.

3.3.77.1 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.

3.3.77.2 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, 2019]

3.3.77.3 Pressure-Reducing Valve. A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions. [14, 2019]

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

3.3.77.4.1 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.

3.3.77.5 Suction Pressure Regulating 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.

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

3.3.78 Variable Speed Pumps and Controllers.

3.3.78.1 Self-Regulating Control. The portion of a self-regulating variable speed fire pump unit that controls the pump speed and power.

3.3.78.2* Self-Regulating Variable Speed Fire Pump Unit. A factory-built integrated fire pump unit consisting of pump, driver, and variable speed control unit, configured to maintain the set pressure until the maximum pump brake horsepower is reached, while acting as a variable speed pressure limiting control and/or a variable speed suction limiting control.

3.3.78.3 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.

3.3.78.4 Variable Speed Pump. A fire pump with variable speed pressure limiting control or a self-regulating variable speed fire pump unit.

3.3.78.5 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.

3.3.79 Velocity Head (h_v). See 3.3.30.6.

Δ 3.3.80* Vertical Fire Protection Zone. The portion of a vertical fire protection system of standpipes with hose valves, sprinkler systems with sprinkler system connections, or combination standpipe sprinkler systems that are supplied by a fire pump(s) or a water storage tank(s) where the static pressure difference between levels is only a function of the elevation difference.

3.3.81 Very Tall Building. A high-rise building where the fire protection water demand exceeds the pumping capacity of the fire department.

3.3.82 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. 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.

4.2* 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.

Δ 4.2.3.1 Plans shall be drawn to an indicated scale, on sheets of uniform size.

N 4.2.3.2 Plans shall indicate, at a minimum, the items from the following list that pertain to the design of the system:

- (1) Name(s) of owner and occupant
- (2) Location, including street address
- (3) Point of compass
- (4) Name and address of installing contractor

- (5) Pump make and model number
- (6) Pump rating _____ gpm @ _____ psi _____ rpm
- (7) Suction main size, length, location, type and class/schedule of material, and point of connection to water supply, as well as depth to top of pipe below grade
- (8) Water storage tank, if applicable
- (9) Size and type of valves, regulators, meters, and valve pits, if applicable
- (10) Water supply information including the following flow test information, if applicable:
 - (a) Location and elevation of static and residual test gauge with relation to the elevation reference point
 - (b) Flow location
 - (c) Static pressure, psi (bar)
 - (d) Residual pressure, psi (bar)
 - (e) Flow, gpm (L/min)
 - (f) Date
 - (g) Time
 - (h) Name of person who conducted the test or supplied the information
 - (i) Other sources of water supply, with pressure or elevation
- (11) Pump driver details including manufacturer and horsepower
- (12) Voltage for electric-motor-driven pumps
- (13) Fuel system details for diesel-driven pumps
- (14) Controller manufacturer, type, and rating
- (15) Suction and discharge pipe, fitting, and valve types
- (16) Test connection piping and valves
- (17) Flow meter details, if applicable
- (18) Pressure maintenance pump and controller arrangement including sensing line details, if applicable

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* Means shall be provided for qualified personnel to determine that the fire pump is operating in a satisfactory manner during pump operation.

4.3.2 System Designer.

4.3.2.1 The system designer shall be identified on the system design documents.

4.3.2.2 Acceptable minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction.

4.3.2.3 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

4.3.2.4 Additional evidence of qualification or certification shall be permitted to be required by the authority having jurisdiction.

4.3.3 System Installer.

4.3.3.1 Installation personnel shall be qualified or shall be supervised by persons who are qualified in the installation, inspection, and testing of fire protection systems.

4.3.3.2 Minimum evidence of qualifications or certification shall be provided when requested by the authority having jurisdiction.

4.3.3.3 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 installation 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

4.3.3.4 Additional evidence of qualification or certification shall be permitted to be required by the authority having jurisdiction.

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.

4.3.4.2 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 servicing 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

4.3.4.3 Additional evidence of qualification or certification shall be permitted to be required by the authority having jurisdiction.

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.)

4.4.3* A single entity shall be designated as having responsibility for acceptable unit performance of the pump, driver, controller, and transfer switch equipment as required by this standard.

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.

4.5.1.1 For water mist positive displacement pumping units, certified shop test data, including flow, pressure, and horsepower, shall be provided for each independent pump.

4.5.1.2 For a multistage multiport pump, certified shop test data that include flow, pressure, and horsepower shall be provided for each outlet.

4.5.1.3 For water mist positive displacement pumping units, certified shop test data, including flow, pressure, and horsepower, shall also be provided for the fire pump unit with variable speed features deactivated.

4.5.1.3.1 The certified fire pump unit shop test data shall be developed by activating the individual fire pumps in the same operating sequence that the controller will utilize.

4.5.1.4 For water mist positive displacement pumping units with variable speed features, certified shop test data, including flow, pressure, and horsepower, shall also be provided for the fire pump unit with variable speed features activated.

4.5.1.4.1 The certified fire pump unit shop test data shall be developed by activating the individual fire pumps in the same operating sequence that the controller will utilize.

4.5.1.5* For self-regulating variable speed fire pump units, two additional certified test curves showing the flow, net pressure, power, and speed shall be provided for each pump operating under the following conditions:

- (1) In self-regulating variable speed mode with the pump unit operating at constant discharge pressure, as measured by the discharge pressure transducer, through the design duty, and all flow rates from churn beyond 150 percent of rated flow until the maximum **pump brake horsepower** is reached
- (2) In self-regulating variable speed mode with the pump unit operating at constant boost pressure through the design duty, and all flow rates from churn beyond 150 percent of rated flow until the maximum **pump brake horsepower** is reached

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.

4.6.1.1 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.

4.6.1.2 Where a water flow test is used to determine the adequacy of the attached water supply, the test shall have been completed not more than 12 months prior to the submission of working plans, unless otherwise permitted by the authority having jurisdiction.

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.

N 4.6.2.1.1* Where mechanical seals are used as fire pump shaft seals, water supplied to the pump shall be from one of the following:

- (1) Public service main
- (2) Clean water stored in a closed top tank
- (3) Other water supplies having a water quality that meets the pump manufacturer's specifications

N 4.6.2.1.2 Clean water flush for mechanical seals shall be of positive pressure.

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 main cannot provide a flow of 150 percent of the rated flow of the pump at the lowest permissible suction pressure, 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) at the lowest permissible suction pressure, the water supply shall be deemed to be adequate.

4.6.2.3.2 The available flow at the fire pump discharge at the lowest permissible suction pressure shall be a minimum of 100 percent of rated flow.

4.6.2.3.3 The available flow and pressure at the fire pump discharge shall be adequate to meet the maximum fire protection demand.

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 at the lowest permissible suction pressure, but the water supply can provide the greater of 100 percent of the rated flow or the flow demand of the fire protection system(s) at the lowest permissible suction pressure, the head available from the water supply shall be permitted to be calculated on the basis of the maximum flow available at the lowest permissible suction pressure.

4.6.5.3 The head described in 4.6.5.1 and 4.6.5.2 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 8.6.3.1.

4.7.5 Each driver or water mist positive displacement pumping unit 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 Pump.

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

4.8 Self-Regulating Variable Speed Fire Pump Units.

4.8.1 Each variable speed self-regulating control unit shall maintain the factory-certified test data for variable speed operating conditions.

4.8.2 A self-regulating variable speed fire pump unit shall be factory assembled and listed as a unit.

4.8.3 Each self-regulating variable speed fire pump unit shall be provided with an across-the-line fire pump controller in accordance with Chapter 10.

4.8.4 When alternate power is provided for the pump, an across-the-line combination fire pump controller/transfer switch designed and installed in accordance with Chapter 10 shall be provided.

4.8.5 As a minimum, each variable speed drive control unit shall be provided in a National Electrical Manufacturers Association (NEMA), Type 4, watertight enclosure with an ingress protection (IP) rating of IP66.

4.8.6 Each self-regulating variable speed fire pump unit shall be provided with a minimum of 5 percent line reactance on the input.

4.8.7 The output current rating of the variable frequency drive (VFD) as marked on the nameplate of the controller shall not be exceeded when operating the motor at the maximum pump horsepower in accordance with 4.11.3.

4.8.8 Self-regulating variable speed fire pump units shall monitor the suction pressure, discharge pressure, the power draw, and the calculated flow rate and provide a supervisory alarm signal to the controller whenever the results do not match the design curve of the unit.

4.8.9 Self-regulating variable speed fire pump units shall monitor the variable speed drive and provide a supervisory alarm signal to the controller whenever any of the following conditions occur:

- (1) Pump run
- (2) High temperature
- (3) Overcurrent
- (4) Overvoltage
- (5) Undervoltage
- (6) Ground fault
- (7) Phase loss
- (8)* Set pressure not met
- (9) Overpressure
- (10) Bypass mode

4.8.9.1 Remote contacts that close to indicate an alarm shall be provided for connection to the controller.

4.8.10 A self-regulating variable speed fire pump unit shall have a visible display panel capable of showing, as a minimum, set pressure, maximum permissible power draw, all phase-to-phase voltages, all phase amperages, boost pressure, calculated rpm, calculated flow, alerts, and faults with an accuracy within ± 2 percent.

4.8.11 Suction and discharge transducers for self-regulating variable speed fire pump units shall be provided and protected from mechanical damage.

4.8.12 Self-regulating variable speed fire pump units shall capture and maintain all operating information for a minimum of 2 years.

4.8.13 A minimum clear working space in accordance with 110.26(A)(1) of *NFPA 70* shall be provided for the pump, variable speed driver, and self-regulating control unit.

4.8.14 The unit shall have no resonant first-order harmonic critical speed below 120 percent of maximum operating speed in either self-regulating or manual operator mode, whichever is greater.

4.8.15 Means shall be provided on each self-regulating variable speed fire pump unit to field adjust the set pressure.

4.8.15.1 The adjustment shall be secured by password protection or other equivalent means.

4.8.16* When operating under no-flow conditions, each self-regulating variable speed fire pump unit shall operate at a speed that provides at least 25 percent of its rated pressure.

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

4.8.18 All motor-starting contactors shall comply with 10.4.5.1.

4.8.19 An automatic bypass shall be provided in accordance with 10.10.3 and 10.10.4.2.

4.8.20 An emergency-run mechanical control shall be provided in accordance with 10.5.3.2.

4.8.21 Circuit protection shall be provided in the VFD path in accordance with 10.10.5.

4.8.22 The assembly shall be marked with the short-circuit current rating.

4.8.23 Local control shall be in accordance with 10.10.7.1 and 10.10.7.3.

4.8.24 The maximum operating frequency shall not exceed line frequency.

4.9 Multistage Multiport Pump.

4.9.1 Multistage multiport fire pumps shall be installed in accordance with this standard.

4.9.2 A shutoff valve shall not be required between the impellers of a multistage multiport pump.

4.10* Centrifugal Fire Pump Capacities.

4.10.1 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.

4.10.2* Centrifugal fire pumps shall have one of the rated capacities in gpm (L/min) identified in Table 4.10.2 and shall be rated at net pressures of 40 psi (2.7 bar) or more.

4.10.3 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.

4.11 Nameplate.

4.11.1 Pumps shall be provided with a nameplate.

4.11.2 The name plate shall be made of and attached using corrosion resistant material.

4.11.3 The nameplate shall indicate the maximum pump horsepower demand required to power the pump at any flow, including flows beyond 150 percent of the rated capacity.

Table 4.10.2 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		

4.12 Pressure Gauges.

4.12.1 Discharge.

4.12.1.1 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.

4.12.1.2 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).

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

4.12.2* Suction.

4.12.2.1 Unless the requirements of 4.12.2.4 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.

4.12.2.1.1 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.

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

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

4.12.2.4 The requirements of 4.12.2 shall not apply to vertical shaft turbine-type pumps taking suction from a well or open wet pit.

4.13 Circulation Relief Valve.

4.13.1 General Requirements.

4.13.1.1* Where an electric variable speed pump is installed, the automatic circulation relief valve shall open at the minimum speed.

4.13.1.2 Unless the requirements of 4.13.1.8 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.

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

4.13.1.3.1 For multistage multiport pumps, the automatic circulation relief valve shall be installed before the discharge check valve for the last port and set below the churn pressure of the first port.

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

4.13.1.5 Provisions shall be made for discharge to a drain.

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

4.13.1.7 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).

4.13.1.8 The requirements of 4.13.1 shall not apply to engine-driven pumps for which engine cooling water is taken from the pump discharge.

4.14* Equipment Protection.

4.14.1* 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, wind-storm, freezing, vandalism, and other adverse conditions.

4.14.1.1* Indoor Fire Pump Units.

4.14.1.1.1 Except as permitted in 4.14.1.1.3, 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).

4.14.1.1.2* Except as permitted in 4.14.1.1.3, 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 4.14.1.1.2.

4.14.1.1.3* Fire pump units supplying a local application fire protection system(s) shall be physically separated from the hazard being protected in a manner that will prevent a fire associated with the hazard from directly exposing the pumping unit.

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

4.14.1.1.5* Except as permitted in 4.14.1.1.6, rooms containing fire pumps shall be free from storage, equipment, and penetrations not essential to the operation of the pump and related components.

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

4.14.1.1.7 The pump room or pump house shall be sized to fit all of the components necessary for the operation of the fire pump and to accommodate the following:

- (1) Clearance between components for installation and maintenance
- (2) Clearance between a component and the wall for installation and maintenance
- (3) Clearance between energized electrical equipment and other equipment in accordance with *NFPA 70*
- (4) Orientation of the pump to the suction piping to allow compliance with 4.16.6.3

Table 4.14.1.1.2 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)

4.14.1.2 Outdoor Fire Pump Units.

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

4.14.1.2.2 Outdoor installations shall be required to be provided with protection against possible interruption in accordance with 4.14.1.

4.14.1.3 Fire Pump Buildings or Rooms with Diesel Engines. Fire pump buildings or rooms enclosing diesel engine pump drivers and fuel tanks shall be protected with an automatic sprinkler system installed in accordance with NFPA 13 as an Extra Hazard Group 2 occupancy.

4.14.1.4 Fire Pump Buildings or Rooms with Electric Drivers. For buildings that are required to be sprinklered, fire pump buildings or rooms enclosing electric fire pump drivers shall be protected with an automatic sprinkler system installed in accordance with NFPA 13 as an Ordinary Hazard Group 1 occupancy.

4.14.2 Equipment Access.

4.14.2.1 The location of and access to the fire pump room(s) shall be pre-planned with the fire department.

4.14.2.1.1 Except as provided in 4.14.2.1.1.1, fire pump rooms not directly accessible from the outside shall be accessible through a fire-resistant-rated corridor from an enclosed stairway or exterior exit.

4.14.2.1.1.1 Fire pump units supplying only local application fire protection systems shall be accessible by a path that is not subject to exposure from a fire in any hazard protected by the fire pump.

4.14.2.1.1.2 Where a fire pump is installed in a parking garage or some other portion of a building separated from the rest of the building by fire-rated construction equivalent to the pump room, and the portion of the building containing the fire pump is protected by a sprinkler system that does not rely on the fire pump, the protected access to the pump room shall not be required.

4.14.2.1.2 The portions of the building needed for the access, as required by 4.14.2.1.1, shall have a fire resistance rating not less than the fire resistance rating of the fire pump room.

4.14.3 Heat.

4.14.3.1 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 (4°C).

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

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

4.14.5 Emergency Lighting.

4.14.5.1 Pump rooms shall be provided with emergency lighting.

4.14.5.2 The intensity of illumination in the pump room(s) shall be 3.0 ft-candles (32.3 lux), unless otherwise specified by a requirement recognized by the authority having jurisdiction.

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

4.14.5.4 The emergency lighting shall be capable of maintaining the lighting level for a minimum of 2 hours.

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

4.14.7* Drainage.

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

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

4.14.8 Guards. Couplings and flexible connecting shafts shall be installed with a coupling guard in accordance with Section 7 of ANSI B11.19, *Performance Requirements for Safeguarding*.

4.15 Pipe and Fittings.

4.15.1* Steel Pipe.

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

4.15.1.2 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.

4.15.1.3 Thick bituminous linings shall not be used.

4.15.2* Joining Method.

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

4.15.2.2 Slip-type fittings shall be permitted to be used where installed as required by 4.16.6 and where the piping is mechanically secured to prevent slippage.

4.15.2.3 The piping around check valves installed per 4.32.4.1, orifice unions, orifice plates, flowmeters, and other devices that have restricting orifices shall have a means to perform an internal inspection or a means to disassemble the piping to allow for the internal inspection of the restricting orifice(s).

4.15.3 Restricting Orifice Identification. Check valves installed per 4.32.4.1, orifice unions, orifice plates, and other devices with a restricting orifice shall have a permanent tag or other means of identification indicating that a restricting orifice is present.

4.15.4 Concentrate and Additive Piping.

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

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

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

4.15.6* Piping, Hangers, and Seismic Bracing.

4.15.6.1 The support of pipe and fittings shall comply with the requirements of Chapter 17 of NFPA 13.

4.15.6.2 The seismic protection, where applicable, of pipe and fittings shall comply with the requirements of Chapter 18 of NFPA 13.

4.15.7* 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.

4.16 Suction Pipe and Fittings.

4.16.1* Components.

4.16.1.1 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.

4.16.1.2 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.

4.16.2 Installation. Suction pipe shall be installed and tested in accordance with NFPA 24.

4.16.3 Suction Size.

4.16.3.1 Unless the requirements of 4.16.3.2 are met, the size of the suction pipe for a single pump or of the suction header pipe for multiple pumps (designed to operate 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 at the lowest permissible suction pressure, as discussed in 4.6.2.3.1), the gauge pressure at the pump suction flanges shall be 0 psi (0 bar) or higher.

4.16.3.2* The requirements of 4.16.3.1 shall not apply where the supply is a suction tank with its water level, after supplying the most demanding system for the required duration, at or above the same elevation as the centerline of the fire pump and the gauge pressure at the pump suction flange does not drop below -3 psi (-0.2 bar) at 150 percent of rated flow when the tank is at its lowest water level.

4.16.3.3 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 4.28.

4.16.4* Pumps with Bypass.

4.16.4.1 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.4.16.4.)

4.16.4.2 For multistage multiport pumps, a bypass shall be installed between the pump suction and the first outlet port and between sequential outlet ports wherever the bypass can provide pressure that is of material value without the impeller. (See Figure A.4.16.4.)

4.16.4.3 The size of the bypass shall be at least as large as the pipe size required for discharge pipe as specified in Section 4.28.

4.16.5* Valves.

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

4.16.5.2 Valve Closure Time.

4.16.5.2.1 Listed indicating valves shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

4.16.5.2.2 Valves with an automatic means to operate the valve shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

4.16.5.3 Automated Valves.

4.16.5.3.1 A listed indicating valve with automated controls shall be permitted.

4.16.5.3.2 The automated water control valve assembly shall meet the following criteria:

- (1) Include a reliable position indication
- (2) Include a valve supervisory switch and be connected to a remote supervisory station
- (3) Operate manually as well as automatically

4.16.5.4 No control valve other than a listed OS&Y valve and the devices as permitted in 4.29.3 shall be installed in the suction pipe within 50 ft (15.3 m) of the pump suction flange.

4.16.6* Installation.

4.16.6.1 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.

4.16.6.2 Freeze Protection.

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

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

4.16.6.3 Elbows and Tees.

4.16.6.3.1 Unless the requirements of 4.16.6.3.2 are met, elbows and tees with a centerline plane parallel to a horizontal split-case pump shaft shall not be permitted. *(See Figure A.4.16.6.)*

4.16.6.3.2 The requirements of 4.16.6.3.1 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.

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

4.16.6.4 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.

4.16.6.5 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).]*

4.16.7 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.

4.16.8* Suction Screening.

4.16.8.1 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.

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

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

4.16.8.4 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.

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

4.16.8.6 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.

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

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

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

4.16.8.10 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.

4.16.8.11 Screens shall have at least 62.5 percent open area.

4.16.8.12 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.

4.16.8.13 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.)*

4.16.9* Devices in Suction Piping.

4.16.9.1 No device or assembly, unless identified in 4.16.9.2, 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.

4.16.9.2 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 and installed in accordance with Section 4.29.

- (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) A listed suction diffuser shall be permitted in the fire pump suction.
- (6) Other devices specifically permitted or required by this standard shall be permitted.

4.16.10* Anti-Vortex Plate. Where a tank is used as the suction source for a fire pump, the discharge outlet of the tank shall be equipped with an assembly that controls vortex flow in accordance with NFPA 22.

4.17 Discharge Pipe and Fittings.

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

4.17.2 For multistage multiport pumps, the discharge components for each port shall consist of pipe, valves, and fittings extending from the pump port discharge flange to the system side of the discharge valve for that port.

4.17.3 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.

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

4.17.5 All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 13.

4.17.6* The size of pump discharge pipe and fittings shall not be less than that given in Section 4.28.

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

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

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

4.17.10 Low Suction Pressure Controls.

4.17.10.1 Suction pressure regulating valves that are listed for fire pump service and that are suction pressure sensitive shall be permitted where the authority having jurisdiction requires positive pressure to be maintained on the suction piping.

4.17.10.2 Where a suction pressure regulating valve is used, it shall be installed according to manufacturers' recommendations in the piping between the pump and the discharge check valve.

4.17.10.3 The size of the suction pressure regulating valve shall not be less than that given for discharge piping in Section 4.28.

4.17.10.4 The friction loss through a suction pressure regulating valve in the fully open position shall be taken into account in the design of the fire protection system.

4.17.10.5 System design shall be such that the suction pressure regulating valve is in the fully open position at the system design point and at 100 percent of rated flow.

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

4.18* Valve Supervision.

4.18.1 Supervised Open. Where provided, the suction valve, discharge valve, bypass valves, and isolation valves on the back-flow 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

4.18.2 Supervised Closed. Control valves located in the pipeline to the hose valve header shall be supervised closed by one of the methods allowed in 4.18.1.

4.19* Protection of Piping Against Damage Due to Movement. A clearance shall be provided around pipes that pass through walls, ceilings, or floors of the fire pump room enclosure.

4.19.1 Unless the requirements of 4.19.2 through 4.19.4 are met, where pipe passes through walls, ceilings, or floors of the fire pump room enclosure, the holes shall be sized such that the diameter of the hole is nominally 2 in. (50 mm) larger than the pipe.

4.19.2 Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (50 mm) larger than the nominal diameter of the pipe shall be acceptable.

4.19.3 No clearance is required if flexible couplings are located within 1 ft (305 mm) of each side of the wall, ceiling, or floor.

4.19.4 Where protection of piping against damage caused by earthquakes is required, the provisions of Section 4.30 shall apply.

4.19.5 Where required, the clearance shall be filled with flexible material that is compatible with the piping materials and maintains any required fire resistance rating of the enclosure.

4.20 Relief Valves for Centrifugal Pumps.

4.20.1* General.

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

4.20.1.2 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.

4.20.1.3 Where an electric variable speed pump or a diesel pressure limiting 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.

4.20.1.3.1 Where an electric variable speed pump or diesel pressure limiting driver is used, the pressure relief valve shall be set to a minimum of 10 psi (0.68 bar) above the set pressure of the variable speed pressure limiting control.

4.20.2 Size. The relief valve size shall be determined by one of the methods specified in 4.20.2.1 or 4.20.2.2.

4.20.2.1* 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.

4.20.2.2 If the relief valve is not sized hydraulically, the relief valve size shall not be less than that given in Section 4.28. (See also 4.20.7 and A.4.20.7 for conditions that affect size.)

4.20.3 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.

4.20.4 Type.

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

4.20.4.2 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.

4.20.5* Discharge.

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

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

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

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

4.20.5.5 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.

4.20.6 Discharge Piping.

4.20.6.1 Except as permitted in 4.20.6.2, the relief valve discharge pipe shall be of a size not less than that given in Section 4.28.

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

4.20.6.2 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.

4.20.6.3 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.

4.20.6.4 Relief valve discharge piping from a single fire pump returning water back to the supply source shall be permitted to be combined with fire pump test piping downstream of any control valve in a manner that complies with 4.20.6, 4.22.2, and 4.22.3.

4.20.6.5 The discharge piping from multiple relief valves shall not be combined with fire pump test piping.

4.20.6.6 Isolation of the test header piping from the pressure relief valve discharge shall be possible.

4.20.7* 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.

4.20.7.1 Where a pressure relief valve has been piped back to suction, a circulation relief valve sized in accordance with 4.13.1.7 and 4.20.7 and discharged to atmosphere shall be provided downstream of the pressure relief valve. The circulating relief valve shall actuate below the opening set point of the pressure relief valve to ensure cooling of the pump during churn operation.

4.20.7.2 Where pump discharge water is piped back to pump suction and the pump is driven by a diesel engine with heat exchanger cooling, the controller shall provide a visual indicator and audible alarm and stop the engine when a high cooling water temperature signal as required by 11.2.4.4.8 is received, provided there are no active emergency requirements for the pump to run.

4.20.7.2.1 The requirements of 4.20.7.2 shall not apply when pump discharge water is being piped back to a water storage reservoir.

4.20.8* 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.

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

4.21 Pumps Arranged in Series.

4.21.1 Series Fire Pump Unit Performance.

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

4.21.1.2 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.

4.21.1.2.1 The discharge pressure shall **reestablish within 20 seconds** whenever the flow condition changes.

4.21.1.3 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.)

4.21.2 Series Fire Pump Unit Arrangement.

4.21.2.1* Except as permitted by 4.21.2.2, all the pumps that are a part of a series fire pump unit shall be located within the same fire pump room.

4.21.2.2 Pumps that are a part of a series fire pump unit shall be permitted to be located in separate pump rooms where all the following conditions are met:

- (1) Each pump shall be arranged so that all pumps operating in series can be manually stopped or started from all pump rooms housing the series fire pumps.
- (2) The suction and discharge pressures from all pumps operating in series shall be displayed in all pump rooms housing the series fire pumps.
- (3) The alarms and signals shall be annunciated in the other pump rooms for all pumps that are a part of the series fire pump unit in accordance with 4.21.2.8 and 4.21.2.9.
- (4) The interconnect control wiring between the controllers in different pump rooms shall comply with 4.21.2.8 and 4.21.2.9.
- (5) A pump room communication system that shall comply with 4.21.2.9 and 4.21.2.10.

4.21.2.3 No more than three pumps shall be allowed to operate in series as a part of a series fire pump unit.

4.21.2.4 No more than two variable speed pumps shall be allowed to operate in series as a part of a series fire pump unit.

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

4.21.2.6 No pressure-reducing or pressure-regulating valves shall be installed between fire pumps arranged in series as a part of a series fire pump unit.

4.21.2.7 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.

4.21.2.8 Protection of Control Wiring for Series Fire Pump Units.

4.21.2.8.1* Interconnected control wiring of fire pumps in series that are not located in the same room and that affect the starting of the supply (lower zone) pump(s) shall be protected against fire and physical damage in the same manner as power conductors described in *NFPA 70*, Article 695.

4.21.2.8.1.1 The motor on the supply (lower zone) pump(s) shall start on the opening of the control circuit (remote start) loop.

4.21.2.8.1.2 The installed controllers shall meet the requirements of 10.5.2.5 or 12.7.2.5 as applicable.

4.21.2.9 Status Signals for Series Fire Pump Units.

4.21.2.9.1 Audible and visual status signals shall be provided in each pump room indicating the status of the associated series pump(s) not located in the same pump room.

4.21.2.9.1.1 The following audible and visual signals shall be provided in each pump room for each series electric fire pump(s).

- (1) Pump running in accordance with 10.4.7.2.1
- (2) Phase loss in accordance with 10.4.7.2.2

- (3) Phase reversal in accordance with 10.4.7.2.3
- (4) Controller connected to alternative source in accordance with 10.4.7.2.4
- (5) Alternate circuit breaker open or tripped in accordance with 10.8.3.12.1
- (6) Low suction pressure — suction pressure more than 10 psi (0.68 bar) below the design suction pressure on any downstream series pump(s)

4.21.2.9.1.2 The following audible and visual signals shall be provided in each pump room for each series diesel fire pump(s).

- (1) Pump running in accordance with 12.4.2.3(1)
- (2) Control switch in off or manual position in accordance with 12.4.2.3(2)
- (3) Trouble on controller or engine in accordance with 12.4.2.3(3)
- (4) Low suction pressure — suction pressure more than 10 psi (0.68 bar) below the design suction pressure on any downstream series pump(s)

4.21.2.9.2 Series fire pump controller(s) shall be provided with additional contacts for remote indication in accordance with 4.21.2.9.1.1 or 4.21.2.9.1.2.

4.21.2.9.2.1 Where other means are used to communicate this information, additional contacts in 4.21.2.9.2 shall not be required.

4.21.2.10 Communications for Series Fire Pump Units.

4.21.2.10.1 A two-way, in-building emergency services communications system in accordance with *NFPA 72* shall be provided in each pump room where pumps in series are not located in the same room.

4.21.2.10.1.1 The communication system shall meet the survivability requirements of *NFPA 72*.

4.22 Water Flow Test Devices.

4.22.1 General.

4.22.1.1* 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.

4.22.1.2 Where multiple pumps are installed, it shall be permitted to manifold the fire pump test discharge piping to a common flow measuring device and discharge.

4.22.1.2.1 Where a single pump can supply the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized for the fire pump with the highest rated flow in accordance with 4.22.2 and 4.22.3.

4.22.1.2.2 Where multiple pumps arranged in series are required to meet the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized for the fire pump with the highest rated flow in accordance with 4.22.2 and 4.22.3.

4.22.1.2.3 Where multiple pumps arranged in parallel are required to operate simultaneously to meet the maximum fire protection system demand, the common piping, flow measuring device, and discharge shall be sized in accordance with 4.22.2 and 4.22.3 for the combined rated flow of all fire pumps required to operate simultaneously.

4.22.1.2.4 The common flow measuring device shall be capable of providing accurate flow measurements when testing a single fire pump and when simultaneously testing all fire pumps required to operate simultaneously.

4.22.1.2.5 A control valve shall be installed on each fire pump test connection upstream of the manifold.

4.22.1.3* 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.

4.22.1.4 The flow shall continue until the flow has stabilized. (See 14.2.6.3.3.)

4.22.1.5* 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.

4.22.2 Meters and Testing Devices.

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

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

4.22.2.3 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.

4.22.2.4 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 4.28.

4.22.2.5 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.

4.22.2.6 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.

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

4.22.2.8 The readout instrument shall be sized for the pump-rated capacity. (See Section 4.28.)

4.22.2.9 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.

4.22.2.10* Where a metering device is installed in a loop arrangement for fire pump flow testing, an alternate means of measuring flow shall be provided.

4.22.2.10.1 The alternate means of measuring flow shall be located downstream of and in series with the flow meter.

4.22.2.10.2 The alternate means of measuring flow shall function for the range of flows necessary to conduct a full flow test.

4.22.2.10.3 An appropriately sized test header shall be an acceptable alternate means of measuring flow.

4.22.3 Hose Valves.

4.22.3.1* General.

4.22.3.1.1 Hose valves shall be listed.

4.22.3.1.2 The number and size of hose valves used for pump testing shall be as specified in Section 4.28.

4.22.3.1.3 Where outlets are being utilized as a means to test the fire pump in accordance with 4.22.1.1, one of the following methods shall be used:

- (1)* Hose valves mounted on a hose valve header with supply pipe sized in accordance with 4.22.3.4 and Section 4.28
- (2) Wall hydrants, yard hydrants, or standpipe outlets of sufficient number and size to allow testing of the pump

4.22.3.2 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.
- (2) Where local fire department connections do not conform to NFPA 1963 and the connection is to be utilized as a wall hydrant, the authority having jurisdiction shall designate the threads to be used.

4.22.3.3 Location.

4.22.3.3.1 A listed indicating butterfly or gate valve shall be located in the pipeline to the hose valve header.

4.22.3.3.2 A drain valve or automatic ball drip shall be located in the pipeline at a low point between the valve and the header. [See Figure A.6.3.1(a) and Figure A.7.2.2.1.]

4.22.3.3.3 The valve required in 4.22.3.3.1 shall be at a point in the line close to the pump. [See Figure A.6.3.1(a).]

4.22.3.4 Pipe Size. The pipe size shall be in accordance with one of the following 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 Section 4.28 shall be used.
- (2) Where the pipe between the hose valve header and the connection to the pump discharge pipe contains more than four fittings that create a change in direction, the next larger pipe size than that required by Section 4.28 shall be used.
- (3)* This pipe shall be permitted to be sized by hydraulic calculations that match the actual test configuration and that include the required pitot pressure and friction loss for the total length of pipe and fire hose plus equivalent lengths of fittings, control valve, and hose valves, plus elevation loss, from the pump discharge flange to the discharge outlets.

4.22.3.4.1 In accordance with 4.28, the installation shall be proven by a test flowing the lesser of 150 percent of rated flow or the maximum flow available at the lowest permissible suction pressure to achieve the required pitot pressure or higher.

4.23 Steam Power Supply Dependability.

4.23.1 Steam Supply.

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

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

4.24 Shop Tests.

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

4.24.2 Preshipment Tests.

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

4.24.2.2 The test pressure shall not be less than one and one-half times the sum of the pump's shutoff head plus its maximum allowable suction head, but in no case shall it be less than 250 psi (17.24 bar).

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

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

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

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

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

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

4.27.1 For pressure-actuated fire pumps, a means to maintain the pressure in the fire protection system shall be provided in accordance with one of the following:

- (1) A pressure maintenance (jockey) pump
- (2) A water mist positive displacement pumping unit in accordance with 8.5.7.2
- (3) Another approved means that is not the main fire pump

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

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

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

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

4.27.5* Excess Pressure.

4.27.5.1 Where a centrifugal-type pressure maintenance pump has a total discharge pressure with the pump operating at shut-off 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.

4.27.5.2 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.

4.27.6 Piping and Components for Pressure Maintenance Pumps.

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

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

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

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

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

4.27.6.6 The pressure sensing line for the pressure maintenance pump shall be in accordance with Section 4.32.

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

4.27.7 Except as permitted in Chapter 8, the primary or standby fire pump shall not be used as a pressure maintenance pump.

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

4.27.9 The pressure maintenance pump shall not be required to have alternate or standby power.

4.28 Summary of Centrifugal Fire Pump Data. The sizes indicated in Table 4.28(a) and Table 4.28(b) shall be used as a minimum.

4.29 Backflow Preventers and Check Valves.

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

4.29.2 Relief Valve Drainage.

4.29.2.1 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.

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

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

Table 4.28(a) Summary of Centrifugal Fire Pump Data (U.S. Customary)

Pump Rating (gpm)	Minimum Pipe Sizes (Nominal) (in.)							
	Suction ^{a,b,c}	Discharge ^a	Relief Valve	Relief Valve Discharge	Meter Device	Number and Size of		Hose Header Supply
						Hose Valves	Nonthreaded Connections	
25	1	1	3/4	1	1 1/4	1 — 1 1/2	1 — 2 1/2	1
50	1 1/2	1 1/4	1 1/4	1 1/2	2	1 — 1 1/2	1 — 2 1/2	1 1/2
100	2	2	1 1/2	2	2 1/2	1 — 2 1/2	1 — 2 1/2	2 1/2
150	2 1/2	2 1/2	2	2 1/2	3	1 — 2 1/2	1 — 2 1/2	2 1/2
200	3	3	2	2 1/2	3	1 — 2 1/2	1 — 2 1/2	2 1/2
250	3 1/2	3	2	2 1/2	3 1/2	1 — 2 1/2	1 — 2 1/2	3
300	4	4	2 1/2	3 1/2	3 1/2	1 — 2 1/2	1 — 2 1/2	3
400	4	4	3	5	4	2 — 2 1/2	1 — 5	4
450	5	5	3	5	4	2 — 2 1/2	1 — 5	4
500	5	5	3	5	5	2 — 2 1/2	1 — 5	4
750	6	6	4	6	5	3 — 2 1/2	1 — 5	6
1000	8	6	4	8	6	4 — 2 1/2	1 — 5	6
1250	8	8	6	8	6	6 — 2 1/2	1 — 5	8
1500	8	8	6	8	8	6 — 2 1/2	1 — 5	8
2000	10	10	6	10	8	6 — 2 1/2	2 — 5 ^d	8
2500	10	10	6	10	8	8 — 2 1/2	2 — 5 ^d	10
3000	12	12	8	12	8	12 — 2 1/2	2 — 5 ^d	10
3500	12	12	8	12	10	12 — 2 1/2	3 — 5 ^d	12
4000	14	12	8	14	10	16 — 2 1/2	3 — 5 ^d	12
4500	16	14	8	14	10	16 — 2 1/2	3 — 5 ^d	12
5000	16	14	8	14	10	20 — 2 1/2	3 — 5 ^d	12

Notes:

(1) The pressure relief valve is permitted to be sized in accordance with 4.20.2.1.

(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.20.6.2.

(3) The flowmeter device is permitted to be sized in accordance with 4.22.2.3.

(4) The hose header supply is permitted to be sized in accordance with 4.22.3.4.

(5) Other types of test outlets, sizes, and quantities are permitted when approved by the authority having jurisdiction.

^aActual diameter of pump flange is permitted to be different from pipe diameter.^bApplies only to that portion of suction pipe specified in 4.16.3.3.^cSuction pipe sizes in Table 4.28(a) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.^dProvide a control valve on each outlet where more than one nonthreaded connection is required.

4.29.2.4 Performance of the requirements in 4.29.2.1 through 4.29.2.3 shall be documented by engineering calculations and tests.

4.29.3 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.

4.29.3.1 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 4.16.5.4.

4.29.4 Evaluation.**4.29.4.1 Backflow Prevention Device.**

4.29.4.1.1 Where a backflow prevention device or assembly is installed in connection with the pump, special consideration

shall be given to the increased pressure loss resulting from the installation.

4.29.4.1.2 Where a backflow prevention device is installed, the final arrangement shall provide effective pump performance at the lowest permissible suction pressure.

4.29.4.1.3 The discharge flow rate shall meet or exceed the fire protection system design flow.

4.29.4.1.4 The discharge flow rate shall meet or exceed 100 percent of the fire pump rated flow rate.

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

4.29.4.1.6 Retroactive installation of a backflow prevention device shall not reduce the suction pressure below that permitted in this standard and accepted by the authority having jurisdiction.

Table 4.28(b) Summary of Centrifugal Fire Pump Data (Metric)

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

Notes:

(1) The pressure relief valve is permitted to be sized in accordance with 4.20.2.1.

(2) The pressure relief valve discharge is permitted to be sized in accordance with 4.20.6.2.

(3) The flowmeter device is permitted to be sized in accordance with 4.22.2.3.

(4) The hose header supply is permitted to be sized in accordance with 4.22.3.4.

(5) Other types of test outlets are permitted when approved by the authority having jurisdiction.

^aActual diameter of pump flange is permitted to be different from pipe diameter.^bApplies only to that portion of suction pipe specified in 4.16.3.3.^cSuction pipe sizes in Table 4.28(b) are based on a maximum velocity at 150 percent rated capacity to 15 ft/sec (4.6 m/sec) in most cases.^dProvide a control valve on each outlet where more than one nonthreaded connection is required.

4.29.4.1.7 Retroactive installation of a backflow prevention device shall not result in a discharge pressure that does not meet the maximum system demand and 100 percent of the rated flow rate for the fire pump.

4.30 Earthquake Protection.

4.30.1 General. Where water-based fire protection systems to be protected against damage from earthquakes, 4.30.2 and 4.30.3 shall apply.

4.30.2* Seismic Loads. Horizontal seismic loads shall be determined in accordance with NFPA 13; ASCE/SEI 7, *Minimum Design Loads for Buildings and Other Structures*; local, state, or international codes; or other sources acceptable to the authority having jurisdiction.

4.30.3 Components.

4.30.3.1 Pump Driver and Controller. The fire pump, driver, and fire pump controller shall be attached to their foundations with materials capable of resisting applicable seismic loads.

4.30.3.2* High Center of Gravity. 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.

4.30.3.3* Pipe and Fittings. Pipe and fittings shall be protected in accordance with NFPA 13.

4.30.3.4 Appurtenances. Seismic protection of appurtenances, including trim pieces, shall be required where they are essential for post-earthquake operation of the fire pump.

4.30.3.4.1* Where seismically protecting smaller diameter trim lines, restraint shall be sufficient.

4.31 Packaged Fire Pump Assemblies.

4.31.1 A packaged fire pump assembly, with or without an enclosure, shall meet all of the following requirements:

- (1) The components shall be assembled and affixed onto a steel framing structure.
- (2) Welders shall be qualified in accordance with the Section 9 of ASME *Boiler and Pressure Vessel Code* or with

the American Welding Society AWS D1.1/D1.1M, *Structural Welding Code — Steel*.

- (3) The assembly shall be listed for fire pump service.
- (4) The total assembly shall be engineered and designed by a system designer as referenced in 4.3.2.
- (5) All plans and data sheets shall be submitted and reviewed by the authority having jurisdiction, with copies of the stamped approved submittals used in the assembly and for record keeping.

4.31.2 All electrical components, clearances, and wiring shall meet the minimum requirements of the applicable *NFPA 70* articles.

4.31.3 Packaged and prefabricated skid unit(s) shall meet all the requirements in this standard, including those described in Sections 4.14 through 4.19.

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

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

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

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

4.31.6 All packaged pump house or pump skids, or both, shall meet the requirements of Section 4.30.

4.31.7 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.

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

4.31.9* The interior floor of a package pump house shall be of solid construction with grading to provide proper drainage for the fire pump components.

4.31.9.1 The interior floor shall be permitted to be provided with grouting in accordance with 4.31.8 or installed after the packaged pump house is set in place in accordance with 4.31.10.

4.31.9.2 The structural frame for a packaged pump house shall be mounted on an engineered footing designed to withstand the live loads of the packaged unit and the applicable wind loading requirements.

4.31.9.3 The foundation footings of a package pump house shall include the necessary anchor points required to secure the package to the foundation.

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

4.32* Pressure Actuated Controller Pressure Sensing Lines.

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

4.32.1.1 Every multistage multiport pump for each discharge port shall have its own individual pressure sensing line connected to the fire pump controller.

4.32.1.1.1 The pressure maintenance pump controller for each discharge port shall have its own individual pressure sensing line.

4.32.2 The pressure sensing line connection for each pump, including jockey pumps, shall be made between that pump's discharge check valve and discharge isolation valve.

4.32.3* 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.

4.32.4 Check Valves or Ground-Face Unions.

4.32.4.1 Where the requirements of 4.32.4.2 are not met, two bronze or stainless steel check valves shall be installed in the pressure sensing line at least 5 ft (1.52 m) apart with a nominal ⅜ in. (2.4 mm) hole drilled in the bronze or stainless steel clapper to serve as dampening. [See Figure A.4.32(a) and Figure A.4.32(b).]

4.32.4.2 Where the water is clean, ground-face unions with noncorrosive diaphragms drilled with a nominal ⅜ in. (2.4 mm) orifice shall be permitted in place of the check valves.

4.32.5 There shall be two inspection test valves attached to the pressure sensing line that shall consist of a tee, a valve, a second tee with the branch plugged, and a second valve. [See Figure A.4.32(a) and Figure A.4.32(b).]

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

4.32.7 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).

4.33 Break Tanks. Where a break tank is used to provide the pump suction water supply, the installation shall comply with NFPA 22.

4.34 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.)

4.35 Automated Inspection, Testing, and Distance Monitoring of Devices, Meters, and Equipment.

Δ 4.35.1* Automated Inspection and Testing.

N 4.35.1.1 Devices, meters, and equipment utilized to perform automated inspection and testing procedures that are subjected to system pressure, where provided, shall be listed.

N 4.35.1.2 Components that are subjected to system pressure but do not affect the fire pump's performance shall not be required to be listed.

Δ 4.35.2* Distance Monitoring.

N 4.35.2.1 Devices, meters, and equipment utilized to perform distance monitoring of system or component status that are subjected to system pressure, where provided, shall be listed.

N 4.35.2.2 Components that are subjected to system pressure but do not affect the fire pump's performance shall not be required to be listed.

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 in accordance with 3.3.31.

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

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

5.3 Water Supply Tanks.

5.3.1 Where provided, water tanks shall be installed in accordance with NFPA 22.

5.3.2 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.

5.4 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 required.

5.5 Alternate Power. Where electric motor-driven fire pump(s) are used, a reliable alternate source of power in accordance with Section 9.6 or a back-up fire pump in accordance with Section 9.3 shall be provided for the fire pump installation.

5.6* Very Tall Buildings.

5.6.1 Water Supply Tanks for Very Tall Buildings.

5.6.1.1* Where the primary supply source for a vertical fire protection zone is stored water within the building, each zone shall be supplied by a minimum of two tanks.

5.6.1.1.1 A water tank shall be permitted to be divided into compartments such that the compartments function as individual tanks.

5.6.1.1.2* The total volume of all tanks or compartments supplying a vertical fire protection zone shall be sufficient for the full fire protection demand in that zone.

5.6.1.1.3 Each individual tank or compartment directly supplying a vertical fire protection zone shall be sized so that at least 50 percent of the fire protection demand is stored with any one compartment or tank out of service.

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

5.6.1.3 A manual refill valve shall be provided for each tank or tank compartment.

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

5.6.1.5 The refill rate shall be sustainable for the required water supply duration.

5.6.1.6* The automatic and manual fill valve combination for each tank or tank compartment shall have its own connection to one of the following:

- (1) A standpipe riser for a zone that is not supplied from the tank served by the refill valve and is provided with a backup fire pump
- (2) A gravity feed express or standpipe riser for a zone that is not supplied from the tank served by the refill valve
- (3) A dedicated riser from a fire pump located below the refill valve
- (4) A reliable domestic riser sized to meet the requirements of 5.6.1.4

5.6.1.6.1* Each refill connection shall be made to a different riser.

5.6.1.6.2 The refill connections shall be interconnected.

5.6.1.6.2.1 When the refill valves are connected to different zones, check valves shall be installed in each standpipe connection to prevent cross flow between the different zones.

5.6.1.6.2.2 Isolation valves shall be provided on both sides of each check valve required by 5.6.1.6.2.1.

5.6.1.6.3 Isolation valves shall be provided between each interconnection.

5.6.1.6.4 When at least one of the tank valves is fed from below, the primary fill shall be from below.

5.6.1.6.4.1* When the fill valves are connected to different zones, the isolation valve shall be permitted to be normally closed to assure that the primary refill is the first refill to operate.

5.6.1.6.5* Each tank shall be provided with an overflow sized for the maximum refill rate with a single automatic refill valve operating fully open.

5.6.1.6.6 The overflow shall be piped to a safe discharge location.

5.6.2 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 one of the following:

- (1) A fully independent and automatic backup fire pump unit(s) arranged so that all zones can be maintained in full service with any one pump out of service.
- (2) An auxiliary means that is capable of providing the full fire protection demand and that is acceptable to the authority having jurisdiction.

Chapter 6 Centrifugal Pumps

6.1 General.

6.1.1* Application.

6.1.1.1 This chapter shall apply to centrifugal pumps 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.

6.1.1.4* Application. Centrifugal pumps addressed in this chapter 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. (See Figure A.6.2.)

6.2.1.1 Each discharge outlet in a multistage multiport pump shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. (See Figure A.6.2.)

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

6.2.2.1 For each discharge outlet in a multistage multiport pump, the shutoff head shall not exceed 140 percent of rated head for any type pump. (See Figure A.6.2.)

6.2.2.2 When operating below the rated speed in a self-regulating mode, a self-regulating variable speed fire pump unit shall maintain the discharge pressure within 5 percent of the set pressure.

6.2.2.3 When operating below the rated speed with a variable speed pump in suction control mode, a variable speed fire pump shall maintain the suction pressure at or above the lowest permissible suction pressure with an accuracy of $-0/+3$ psi ($-0/+0.2$ bar).

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 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 or diesel engine drivers shall be connected by a flexible coupling or flexible connecting shaft.

6.5.1.2* Flexible couplings and flexible connecting shafts shall be listed for fire pump service and installed in accordance with the listing.

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 ANSI/HI 1.4, *Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation and Maintenance*. (See A.6.5.)

Chapter 7 Vertical Shaft Turbine-Type Pumps

7.1* General.

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

7.1.2 Factory and Field Performance.

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. (See Figure A.6.2.)

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.)

7.1.2.3 The vertical turbine-type pump shall be designed to operate in a vertical position with all parts in correct alignment.

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 Submergence of the pump bowls shall be provided for reliable operation of the fire pump unit.

7.2.2.1.2 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.)

7.2.2.1.3* 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 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.

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.)

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

7.3.2.5 Where the pump is of the enclosed lineshaft 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 lineshafting 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 4.12.1
- (4) Relief valve and discharge cone where required by 4.20.1
- (5) Hose valve header and hose valves as specified in 4.22.3 or metering devices as specified in 4.22.2

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 4.14 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 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 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 15,000 hours.

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 mechanism.

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 vertical turbine pumps using right-angle gear drives driven by a diesel engine, a listed torsional coupling shall be used and mounted on the engine side of the driveshaft.

7.5.1.6.1.1 For drive systems that include a diesel engine, torsional coupling, right-angle gear drive, and vertical shaft pump, the pump manufacturer shall provide, at a minimum, a 3-mass torsional frequency calculation, indicating that the first two natural frequencies of the system and the critical speeds associated with engine firing frequency are found to be no less than 25 percent above or below when the pump is operating at rated speed.

7.5.1.6.1.2* The torsional frequency calculation specified in 7.5.1.6.1.1 shall include the mass elastic characteristics for a wetted pump with the specific impeller(s) trim, torsional coupling, right-angle gear, gear ratio, flexible connecting shaft, and the engine.

7.5.1.6.1.3* Where the calculations required in 7.5.1.6.1.1 indicate that critical speeds are found to fall less than 25 percent above or below pump rated speed, a further detailed set of forced response calculations shall be required for the vertical and horizontal components indicating there are no damaging vibratory stresses or torques.

7.5.1.6.1.4* The torsional analysis specified in 7.5.1.6.1.3 shall include the mass elastic characteristics required in 7.5.1.6.1.2 plus the following:

- (1) The excitation characteristics of the specific engine and rating
- (2) A fully flexible lumped parameter model having multiple elements along the length of the engine crankshaft, the horizontal shafting, and vertical shafting to all pump stages
- (3) The effect of engine misfire

7.5.1.6.1.5 For a system defined in 7.5.1.6.1 that uses a variable speed diesel driver, the operating speed for the analytical speeds shall be defined as not less than 25 percent above the pump rated speed and not less than 25 percent below the lowest possible speed of the variable speed driver.

7.5.1.6.1.6 The torsional coupling required in 7.5.1.6.1 shall be permitted to be omitted when a complete mass elastic

system torsional analysis is provided and accepted by the authority having jurisdiction and indicates that the system meets the requirements of 7.5.1.6.1.3 without a torsional coupling being included in the system.

7.5.1.6.1.7 In addition to the requirements of 7.5.1.6.1.3, results shall include engine critical response, crankshaft stress, and crankshaft damper heat dissipation.

7.5.1.6.2 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 less than 25 percent above or below the operating speed of the pump and driver.

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.

7.5.1.6.4 For vertical turbine pumps using angle gear drives driven by a diesel engine, a torsional coupling shall be used and mounted on the engine side of the driver shaft.

7.5.1.6.4.1 The torsional coupling shall be permitted to be omitted when a mass elastic system torsional analysis is provided and accepted by the authority having jurisdiction.

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 mechanism.

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 a minimum of 15,000 hours of operation, as well as being capable of transferring the minimum and maximum conditions, as defined by the pump manufacturer, 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 Unless the requirements of 7.5.1.4 are met, engines shall be connected to vertical shaft pumps by means of a right-angle gear drive with a listed flexible connecting shaft, which will prevent undue strain on both the engine and the gear drive.

7.5.1.8.2 The flexible connecting shaft shall be listed for this diesel fire pump service.

7.5.1.8.3 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.

7.5.1.8.4 The requirements of 7.5.1.8.1 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, shall not require a right-angle drive, but shall require a non-reverse ratchet.

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 lineshaft 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 ANSI/HI 1.4, *Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation and Maintenance*.

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

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

Chapter 8 Positive Displacement Pumps

8.1* General.

8.1.1 Application. This chapter shall apply to positive displacement pumps as defined in 3.3.51.14.

N 8.1.1.1 The provisions of all other chapters of this standard shall apply unless specifically addressed by this chapter.

N 8.1.1.2 Positive displacement pumps shall be permitted to pump liquids for fire protection applications.

N 8.1.1.3 The selected pump shall be appropriate for the viscosity of the liquid.

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 Pump Seals.

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

8.1.3.2 Packing shall not be used.

8.1.4* Pump Materials. Materials used in pump construction shall be selected based on the corrosion potential of the environment, fluids used, and operational conditions. (See 3.3.13 for definition of corrosion-resistant materials.)

8.1.5 Dump Valve.

8.1.5.1 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.

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

8.1.5.3 Dump Valve Control.

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

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

8.1.5.4 Dump valves shall be listed.

8.1.5.5 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 8.5.2.

8.4 Water Mist Positive Displacement Pumping Units.

8.4.1 Water mist positive displacement pumping units shall be dedicated to and listed as a unit for fire protection service.

8.4.2 Except as provided in 8.4.3 through 8.4.11, all the requirements of this standard shall apply.

8.4.3 Water mist positive displacement pumping units shall include pumps, driver(s), and controller as a complete operating unit.

Δ 8.4.4 Performance.

N 8.4.4.1 The pump controller shall manage the performance of all pumps so that within 20 seconds after any demand to start, pumps shall supply and maintain a stable discharge pressure (± 10 percent) throughout the entire range of operation.

N 8.4.4.2 The discharge pressure shall restabilize within 20 seconds whenever the flow condition changes.

8.4.5 Redundancy shall be built into the units such that failure of a line pressure sensor or primary control board will not prevent the system from working at its full capacity with emergency-run mechanical control in accordance with 10.5.3.2.

8.4.6 Where provided with a variable speed control, one of the following shall apply:

- (1) Failure of the variable speed control feature shall cause the controller to bypass and isolate the variable speed control system.
- (2) There shall be a redundant motor and pump to compensate for the lost variable speed driven pump capacity.

8.4.7 The unit controller shall be arranged so as to comply with all of the following:

- (1) Each motor can be manually operated individually without opening the enclosure door.
- (2) A circuit breaker is incorporated for each motor in accordance with 10.4.3 and 10.4.4.

(3) The controller for each circuit breaker operator is marked to indicate the motor it protects.

N 8.4.7.1 Where a single isolating switch is provided for all the unit controllers, the requirements in 10.4.2 do not apply.

8.4.8 The requirement in 10.3.4.3 shall apply to each individual motor and the entire unit.

N 8.4.9 Water mist positive displacement pumping units shall achieve the system design discharge pressure within the time specified in the listing but not greater than 60 seconds after the start of flow from the smallest nozzle.

N 8.4.10 A permanently marked weatherproof metal or rigid plastic sign shall be affixed to the system that indicates the required time to achieve system design pressure as indicated in 8.4.9.

N 8.4.11 The phase reversal requirements in 10.4.6.2.1, 10.4.6.2.2, and 10.4.7.2.3 shall not be applicable to positive displacement pumps that are able to deliver the required flow and pressure regardless of direction of rotation.

8.5 Fittings.

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

8.5.2* General Information for Relief Valves.

8.5.2.1 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.

8.5.2.2 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.

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

8.5.3* Relief Valves for Foam Concentrate Pumps.

8.5.3.1 For foam concentrate pumps, safety relief valves shall be piped in one of the following ways:

- (1) Connection of the discharge from the safety relief valve to the foam concentrate tank(s)
- (2) Where there is a tank return line, connection of the discharge from the safety relief valve to this line leading back to the tank provided there is no valve of any kind between the relief valve and the foam concentrate tank(s)
- (3) Connection of the discharge from the safety relief valve to the pump suction piping if a means to prevent overheating is provided

8.5.3.2 There shall be no valve between the outlet of the safety relief valve and its connection to the system.

8.5.4* Relief Valves for Water Mist Pumps.

8.5.4.1 Except as provided in 8.5.4.2, safety relief valves on positive displacement water mist pumps shall discharge to a drain or to a water supply at atmospheric pressure.

8.5.4.2 A safety relief valve shall be permitted to discharge into the pump suction where conditions meet both of the following:

- (1) A means is provided to prevent overheating.

- (2) The safety relief valve and pump driver are sized to accommodate the back pressure in the pump suction.

8.5.5* Suction Strainer.

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

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

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

8.5.5.4 Strainer mesh size shall be based on the liquid viscosity of the concentrate and in accordance with the pump manufacturer's recommendation.

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

8.5.7 Pressure Maintenance.

8.5.7.1 Except as permitted in 8.5.7.2, the primary or standby fire pump shall not be used as a pressure maintenance pump.

8.5.7.2 Water mist positive displacement pumping units shall be permitted to maintain system pressure under one of the following conditions:

- (1) Pumping unit is designed and listed to alternate pressure maintenance duty between two or more pumps with variable speed pressure-limiting control, and provide a supervisory signal wherever pressure maintenance is required more than two times in one hour.
- (2) Pumping unit is designed and listed to have a redundant pump when one primary pump is used for pressure maintenance duty with variable speed pressure-limiting control, and provide a supervisory signal wherever pressure maintenance is required more than two times in one hour.
- (3) Pumping unit is designed to use dedicated pressure maintenance pump that is not required for primary fire pump service and provides a supervisory signal whenever pressure maintenance is required more than two times in one hour.

Δ 8.5.7.3 When in the pressure maintenance mode, water mist positive displacement pumping units shall comply with 8.4.9 when the smallest system nozzle is discharged at the standby pressure.

8.5.7.4 A single sensing line shall be permitted to be used for a water mist positive displacement pumping unit controller where the unit also serves for pressure maintenance on a water mist system.

8.6 Pump Drivers.

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

8.6.2 Reduction Gears.

8.6.2.1 If a reduction gear is provided between the driver and the pump, it shall be listed for the intended use.

8.6.2.1.1 Reduction gears shall meet the requirements of ANSI/AGMA 2011-B14, *Cylindrical Wormgearing Tolerance and Inspection Methods*.

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

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

8.6.2.4 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.

8.6.2.4.1 For variable speed drives, the analysis of 8.6.2.4 shall include all speeds down to 25 percent below the lowest operating speed obtainable with the variable speed drive.

8.6.3 Common Drivers.

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

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

8.7* Controllers. See Section 8.4 and Chapters 10 and 12 for requirements for controllers.

8.8 Foundation and Setting.

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

8.8.2 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.

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

8.9 Driver Connection and Alignment.

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

8.9.2 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.

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

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

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

8.10 Flow Test Devices.

8.10.1 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.

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

8.10.3 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 excepting 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*, 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.

9.1.8* Interruption.

9.1.8.1 No ground fault interruption means shall be installed in any fire pump control or power circuit.

9.1.8.2 No arc fault interruption means shall be installed in any fire pump control or power circuit.

9.1.8.3 Arc-resistant equipment shall be permitted.

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*

9.2.3 For fire pump installations using the arrangement in 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 requirements:

- (1) It shall be identified as being suitable for use as service equipment.
- (2) It shall be lockable in both the closed position and the open position.
- (3)* It shall be located remote from other building disconnecting means.
- (4)* It shall be located remote from other fire pump source disconnecting means.
- (5) It 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 having to open 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) Where the disconnecting means is located within fenced enclosures or in buildings under the control of the owner, sealing the disconnecting means and performing approved weekly recorded inspections

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 largest pump motor and the full-load current of all of the other pump motors and accessory equipment.

9.2.3.4.1 Alternatively, compliance with 9.2.3.4 shall be based on an assembly listed for fire pump service that complies with the following:

- (1) The overcurrent protection device shall not open within 2 minutes at 600 percent full-load current.
- (2) The overcurrent protection device shall not open with a restart transient of 24 times the full-load current.
- (3) The overcurrent protection device shall not open within 10 minutes at 300 percent full-load current.
- (4) The trip point for circuit breakers shall not be field adjustable.
- (5) The overcurrent protection device shall be identified as being "Suitable for use as Service Equipment."
- (6) Where used as service equipment, the disconnecting means shall be marked "Service Disconnect."
- (7) An instantaneous trip circuit breaker shall be permitted.

9.2.3.4.2 Overcurrent Device Selection. An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent devices specified in 10.8.2.2(2) provided it is part of a transfer switch assembly listed for fire pump service and complies with 9.2.3.4.1.

- N 9.2.3.4.3** An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent device specified in 9.2.3.4 provided it is part of an assembly listed for fire pump service and complies with 9.2.3.4.1.

9.3 Alternate Power.

9.3.1 Unless there is an installed power arrangement as described in 9.3.3, at least one alternative source of power shall be provided for high-rise buildings.

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 for the primary fire pump shall not be required where a backup engine-driven fire pump, backup steam turbine-driven fire pump, or backup electric motor-driven fire pump with independent power source meeting 9.2.2 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

- N 9.3.4.1** For fire pump installations using the arrangement in 9.2.2(1), 9.2.2(2), 9.2.2(3), or 9.2.2(5) for the alternate 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 in accordance with 9.2.3.1 through 9.2.3.4.1.

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.

9.3.6.1 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*.

9.3.6.2 Protective devices shall not be installed in the load side of the power transfer switch.

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, provided a successful start can be demonstrated on the standby generator system. (See 10.5.3.2.)

9.4.2.1* The requirements of 9.4.1 shall apply to the emergency-run mechanical control of the self-regulating variable speed fire pump unit.

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 contactor(s) load terminals to which the motor is connected 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.

9.4.4.1 Wiring from the controller(s) to the pump motor shall be in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, liquidtight flexible metal conduit, or liquidtight flexible nonmetallic conduit Type LFNC-B, listed Type MC cable with an impervious covering, or Type MI cable.

9.4.4.2 Electrical connections at motor terminal boxes shall be made with a listed means of connection.

9.4.4.3 Twist-on, insulation-piercing type, and soldered wire connectors shall not be permitted to be used for this purpose.

9.5 Motors.

9.5.1 General.

9.5.1.1 All motors shall comply with NEMA MG-1, *Motors and Generators*, and shall be marked as complying with NEMA Design B standards for three-phase motors or NEMA Design N or L standards for single-phase motors, and shall be specifically listed for fire pump service. [*See Table 9.5.1.1(a), Table 9.5.1.1(b), and Table 9.5.1.1(c).*]

9.5.1.1.1 Single-phase motors shall be used only in across-the-line starting applications.

9.5.1.1.2 International Electrotechnical Commission (IEC) motors, where used, shall be listed for fire service.

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.

9.5.1.4.1 Motors shall meet the applicable requirements of NEMA MG-1, *Motors and Generators*, Part 30 or 31.

9.5.1.4.2 Motors shall be listed, suitable, and marked for inverter duty.

9.5.1.4.3 Listing shall not be required if 9.5.1.2 applies.

Δ 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 in Table 9.5.1.1(a) by the ratio of 230 V to the voltage rating of the motor.

9.5.1.6 Code letters of motors for all other voltages shall conform with those shown for 230 V in Table 9.5.1.1(a).

9.5.1.7 All motors shall be rated for continuous duty.

Table 9.5.1.1(a) Horsepower and Locked Rotor Current Motor Designation for Three-Phase NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 230 V at 60 Hertz (A)*	Motor Designation (NEMA 70, Locked Rotor Indicating Code Letter) "F" to and Including
1	30	N
1½	40	M
2	50	L
3	64	K
5	92	J
7½	127	H
10	162	H
15	232	G
20	290	G
25	365	G
30	435	G
40	580	G
50	725	G
60	870	G
75	1085	G
100	1450	G
125	1815	G
150	2170	G
200	2900	G
250	3650	G
300	4400	G
350	5100	G
400	5800	G
450	6500	G
500	7250	G

*Locked rotor current values are maximums.

Table 9.5.1.1(b) Horsepower and Locked Rotor Current Motor Designation for Single-Phase NEMA Design N and L Motors

Rated Horsepower	Locked Rotor Current Single-Phase 115 V at 60 Hertz (A)*		Locked Rotor Current Single-Phase 230 V at 60 Hertz (A)*	
	Design N	Design L	Design N	Design L
¼	20	—	12	—
¼	26	—	15	—
⅓	31	—	18	—
½	45	45	25	25
¾	61	61	35	35
1	80	80	45	45
1½	—	—	—	50
2	—	—	—	65
3	—	—	—	90
5	—	—	—	135
7½	—	—	—	200
10	—	—	—	260

*Locked rotor current values are maximums.

Table 9.5.1.1(c) Horsepower and Locked Rotor Current Motor Designation for Three-Phase, 380 V, 50 Hertz, NEMA Design B Motors

Rated Horsepower	Locked Rotor Current Three-Phase 380 V at 50 Hertz (A)*	Motor Designation (NEMA 70, Locked Rotor Indicating Code Letter) "F" to and Including
1	20	P
1½	27	N
2	34	M
3	43	L
5	61	K
7½	84	J
10	107	H
15	154	H
20	194	H
25	243	H
30	289	H
40	387	H
50	482	H
60	578	H
75	722	H
100	965	H
125	1207	H
150	1441	H
200	1927	H
250	2534	H
300	3026	H
350	3542	H
400	4046	H
450	4539	H
500	5069	H

*Locked rotor current values are maximums.

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 used shall be as marked on the motor, but in no case exceed 1.15.

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 drip-proof) 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.

N 9.5.3.3 Fire pump motors that are also listed as inverter duty motors shall be marked with the maximum allowable service factor amps that can be used when connected to a variable frequency drive (VFD).

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.

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

9.6.2.3 The generator 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.

9.6.5.1 Protective devices installed in the fire pump circuits of the on-site generator power source shall allow instantaneous pickup of the full pump room load and shall comply with NFPA 70, Section 700.28.

9.6.5.2 Protective devices in the fire pump circuit shall be supervised by remote monitoring.

9.6.5.3 The fire pump circuit breaker shall not be required to be coordinated with the generator power source protective

device, provided it is used in an individual branch circuit and is coordinated with all other line side protective devices.

▲ 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).
- (4)* Mounting and installation of a junction box shall not affect the short circuit rating of the controller(s).
- (5) As a minimum, a Type 2, dripproof enclosure (junction box) shall be used.
- (6) The enclosure shall be listed to match the fire pump controller enclosure type rating.
- (7) Terminals, junction blocks, and splices, where used, shall be listed.
- (8) Neither a fire pump controller nor a fire pump power transfer switch, where provided, shall be used as a junction box to supply other equipment, including a pressure maintenance (jockey) pump(s). (See 10.3.4.5.1 and 10.3.4.6.)
- (9) Neither a fire pump controller nor a fire pump power transfer switch shall be used as a junction box for wire splices.

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.

9.8.1.1 The junction box shall be installed ahead of the fire pump controller, a minimum of 12 in. (305 mm) beyond the fire-rated wall or floor bounding the fire zone.

9.8.1.2 Single conductors (individual conductors) shall not enter the fire pump enclosure separately.

9.8.2* Where required by the manufacturer of a listed electrical circuit protective system, by *NFPA 70*, or by the listing, the raceway between a junction box and the fire pump controller shall be sealed at the junction box end as required and in accordance with the instructions of the manufacturer. (See *NFPA 70, Article 695*.)

9.8.3 Standard wiring between the junction box and the controller shall be considered 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* 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.

10.1.2.3.1 Controllers shipped in sections shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

10.1.2.3.2 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 equipment assemblies 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*, Article 695, and other applicable documents.

N 10.1.4 Arc Flash Mitigation for Personnel Protection. Controllers shall be provided with arc flash mitigation in accordance with 10.1.4.1 or 10.1.4.2.

N 10.1.4.1 Construction.

N 10.1.4.1.1 Controllers shall be constructed so that the isolating switch, with instantaneous-only overcurrent protection, is located in a separate enclosure or compartment attached to the controller.

N 10.1.4.1.2 The construction of the separate enclosure or compartment shall be both of the following:

- (1) Able to totally isolate incoming normal power from the main enclosure
- (2) Marked to prohibit energized work

N 10.1.4.2 Controllers shall be listed as arc resistant.

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*, 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.

N 10.3.3.2 Controllers with variable-speed pressure-limiting control or variable-speed suction-limiting control shall be securely mounted in, as a minimum, a National Electrical Manufacturers Association (NEMA) Type 12, dusttight enclosure(s) or an enclosure(s) with an ingress protection (IP) rating of IP54.

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

10.3.3.4 The enclosure(s) shall be grounded in accordance with *NFPA 70*, 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 ± 2 percent of motor nameplate voltage and current.

10.3.4.3.1 Where a self-regulating variable speed fire pump unit is applied to the output of the controller, the accuracy of the fire pump controller meters shall not be required to be maintained, and the meters on the self-regulating variable speed fire pump unit shall be used.

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 raceway or as a junction box for any purpose (see Section 9.7), including the following:

- (1) To supply other equipment
- (2) To splice incoming or outgoing wires
- (3) To connect external surge suppression

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.

10.3.4.5.3* Except as provided in 4.21.2.2(1) and 10.9.4, lock-out, remote shutdown, or interlock to prevent normal operation shall not be permitted unless approved by the authority having jurisdiction.

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* Operating and Installation Instructions.

N 10.3.7.3.1 The following basic operating instructions, as a minimum, for emergency response operation of the controller shall be mounted on the exterior of the controller:

- (1) Opening and closing sequence of the normal and emergency isolating switches, if separate from the circuit breaker
- (2) Opening and closing sequence of the normal and emergency circuit breakers
- (3) Operating the emergency-run mechanical control
- (4) Starting the pump by manual electrical means
- (5) Stopping the pump by manual electrical means

N 10.3.7.3.2 The following complete installation instructions, as a minimum, shall be provided with the controller without requiring access to a website or other electronic means:

- (1) Location and size of mounting holes
- (2) Suitable locations for conduit entrance
- (3) Location of plumbing connection
- (4) Input and output lug sizes for power wiring
- (5) Input and output lug sizes for remote alarm and control functions
- (6) External connection drawing

N 10.3.7.3.3 The following advanced operating instructions, as a minimum, for the fire pump controller other than what is required in 10.3.7.3.1 shall be provided with the controller, or, at the option of the manufacturer, based on the model or the serial number, made accessible on the manufacturer's website or through other electronic means:

- (1) Description of the model, including all options
- (2) Product specifications
- (3) Menu functions
- (4) Settings
- (5) Maintenance

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

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 10.3.3.4.)

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 IEEE C62.41, *IEEE Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits*, or where the controller is listed to withstand surges and impulses in accordance with UL 1449, *Surge Protective Devices*.

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 of the controller discussed in 10.1.2.2
- (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

10.4.3.3.1.1* The circuit breaker shall not trip when starting a motor from rest in the across-the-line (direct-on-line) mode, whether or not the controller is of the reduced inrush starting type.

10.4.3.3.1.2* The circuit breaker shall not trip when power is interrupted from a running pump, or if the pump is restarted in less than 3 seconds after being shut down. If a control circuit preventing a re-start within 3 seconds is provided, this requirement shall not apply.

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.

Δ 10.4.4 Locked Rotor Overcurrent Protection.

N 10.4.4.1 A locked rotor overcurrent device is the only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor.

N 10.4.4.2 The locked rotor overcurrent device shall be located within the fire pump controller.

Δ 10.4.4.3 The locked rotor overcurrent device shall possess the following characteristics:

- (1) For a squirrel-cage or wound-rotor induction motor, the device shall be of the time-delay type having tripping times as follows:
 - (a) Between 8 seconds and 12 seconds at locked rotor current
 - (b) Three minutes at a minimum of 300 percent of motor full-load current
- (2) For a direct-current motor, the device shall be as follows:
 - (a) Of the instantaneous type
 - (b) Calibrated and set at a minimum of 400 percent of motor full-load current
- (3) Visual means or markings shall be placed on the device to indicate that required settings have been made.
- (4)* It shall be possible to reset the device for operation immediately after tripping, with the tripping characteristics thereafter remaining unchanged.
- (5) Tripping shall comply with both of the following:
 - (a) Tripping shall be accomplished by opening the circuit breaker.
 - (b) The circuit breaker shall be of the external manual reset type.

10.4.5 Motor Starting Circuitry.

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

10.4.5.1.1 Running contactors shall be sized for both the locked rotor currents and the continuous running currents encountered.

10.4.5.1.2 Starting contactors shall be sized for both the locked rotor current and the acceleration (starting) encountered.

10.4.5.2 Timed Acceleration.

10.4.5.2.1 For electrical operation of reduced-voltage controllers, timed automatic acceleration of the motor shall be provided.

10.4.5.2.2 The period of motor acceleration shall not exceed 10 seconds.

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

10.4.5.4 Starting Reactors and Autotransformers.

Δ 10.4.5.4.1 Starting reactors and autotransformers shall comply with the requirements of UL 508, *Industrial Control Equipment*, Table 92.1.

Δ 10.4.5.4.2 Starting reactors and autotransformers over 200 hp shall be permitted to be designed to Part 3 of UL 508, *Industrial Control Equipment*, Table 92.1, in lieu of Part 4.

10.4.5.5 Soft Start Units.

10.4.5.5.1 Soft start units shall be horsepower rated or specifically designed for the service.

10.4.5.5.2 The bypass contactor shall comply with 10.4.5.1.

10.4.5.5.3 Soft start units shall comply with the duty cycle requirements in accordance with 10.4.5.4.1 and 10.4.5.4.2.

10.4.5.6 Operating Coils.

10.4.5.6.1 For controllers of 500 V or less, the operating coil(s) for any motor contactor(s) and any bypass contactor(s), if provided, shall be supplied directly from the main power voltage and not through a transformer.

10.4.5.6.2 For controllers rated above 500 V but not more than 600 V, a transformer shall be permitted to supply the operating coils referred to in 10.4.5.6.1.

N 10.4.5.6.3 It shall be permitted for dc coils to be powered from the system dc power supply, provided the power supply control circuit is rated for continuous supply of the maximum coil pull-in current, and all other possible loads.

10.4.5.7* Single-Phase Sensors in Controller.

10.4.5.7.1 Sensors shall be permitted to prevent a three-phase motor from starting under single-phase condition.

10.4.5.7.2 Such sensors shall not cause disconnection of the motor if it is running at the time of single-phase occurrence.

10.4.5.7.3 Such sensors shall be monitored to provide a local visible signal in the event of malfunction of the sensors.

10.4.5.8 No ground fault protection (tripping) shall be allowed.

10.4.5.9 A ground fault alarm shall be permitted.

10.4.6* Signal Devices on Controller.

10.4.6.1 Power Available Visible Indicator.

10.4.6.1.1 A visible indicator shall monitor the availability of power in all phases at the line terminals of the motor contactor or of the bypass contactor, if provided.

10.4.6.1.2 If the visible indicator is a pilot lamp, it shall be accessible for replacement.

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

10.4.6.2 Phase Reversal.

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

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

10.4.7* Fire Pump Alarm and Signal Devices Remote from Controller.

10.4.7.1 Where the pump room is not constantly attended, audible or visible signals powered by a separate reliable supervised source not exceeding 125 V shall be provided at a point of constant attendance.

10.4.7.2 These fire pump alarms and signals shall indicate the information in 10.4.7.2.1 through 10.4.7.2.6.

10.4.7.2.1 Pump or Motor Running. The signal shall actuate whenever the controller has operated into a motor-running condition.

10.4.7.2.2 Loss of Phase.

10.4.7.2.2.1 The fire pump alarm shall actuate whenever any phase at the line terminals of the motor contactor is lost.

10.4.7.2.2.2 All phases shall be monitored, which detects loss of phase whether the motor is running or at rest.

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

Δ 10.4.7.2.3 Phase Reversal.

N 10.4.7.2.3.1 The fire pump alarm shall actuate whenever the three-phase power at the line terminals of the motor contactor is reversed.

N 10.4.7.2.3.2 Where power is supplied from multiple power sources, monitoring for phase reversal shall be permitted at any point electrically upstream of the line terminals of the contactor, provided all sources are monitored.

10.4.7.2.4 Controller Connected to Alternate Source. Where two sources of power are supplied to meet the requirements of 9.3.2, this signal shall indicate whenever the alternate source is the source supplying power to the controller.

10.4.7.2.5 Alternate Source Isolating Switch or Circuit Breaker Open. Where two sources of power are supplied to meet the requirements of 9.3.2, a signal shall be provided to indicate that the alternate source isolating switch or circuit breaker is open or tripped.

Δ 10.4.7.2.6 Controller or System Trouble. As a minimum, a controller or system trouble alarm shall actuate whenever any of the following alarms occur:

- (1) Ground-fault signal, where provided (*see 10.4.5.9*)
- (2) Pressure-sensing device signals (*see 10.5.2.1.3.1 and 10.5.2.1.3.2*)
- (3) Variable-speed trouble signals (*see 10.10.8.1, 10.10.8.2, and 10.10.3*)
- (4) Fail-to-start signal (*see 10.5.2.7.5*)

10.4.8 Controller Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions in 10.4.7.2.1 through 10.4.7.2.3 and 10.4.7.2.6 and when a controller is equipped with a transfer switch in accordance with 10.4.7.2.4 and 10.4.7.2.5.

10.5 Starting and Control.

10.5.1* Automatic and Nonautomatic.

10.5.1.1 An automatic controller shall be self-acting to start, run, and protect a motor.

10.5.1.2 An automatic controller shall be arranged to start the driver upon actuation of a pressure switch or nonpressure switch actuated in accordance with 10.5.2.1 or 10.5.2.2.

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

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

10.5.2 Automatic Controller.

10.5.2.1* Water Pressure Control.

10.5.2.1.1 Pressure-Sensing Device.

10.5.2.1.1.1 A pressure-sensing device, either a pressure-actuated switch or electronic pressure sensor, having adjustable high- and low-calibrated set points shall be provided as part of the controller.

10.5.2.1.1.2* Water piping shall not be extended into the controller.

10.5.2.1.1.3 For multistage multiport pumps, a dedicated pressure-sensing device as described in 10.5.2.1.1.1 shall be provided for each discharge port of the pump as part of the controller.

10.5.2.1.1.4 For multistage multiport pumps, a dedicated pressure recorder as described in 10.5.2.1.8.2 shall be provided for each discharge port of the pump as part of the controller.

10.5.2.1.1.5 The requirements of 10.5.2.1.1.1 and 10.5.2.1.1.3 shall not apply in a non-pressure-actuated controller, where the pressure-sensing device shall not be required.

10.5.2.1.2 There shall be no pressure snubber or restrictive orifice employed within the sensing device.

10.5.2.1.3* Where an electronic pressure sensor is used to automatically control fire pump operation, the fire pump controller shall monitor this electronic pressure sensor during automatic testing.

10.5.2.1.3.1* Where the electronic pressure sensor reading exceeds 10 psi (0.68 bar) during any automatic pump start that was initiated by the solenoid drain valve, as required by 10.5.2.7.3, the controller shall activate a visual and audible alarm that can be silenced.

10.5.2.1.3.2* Where an electronic pressure sensor is used to control fire pump operation, the fire pump controller shall monitor and provide a signal for the following electronic pressure sensor conditions:

- (1) Any time the electronic pressure sensor output is less than 10 percent of rated span or below its rated zero pressure output
- (2) Any time the electronic pressure sensor reading is more than 10 percent above its rated full-scale output

10.5.2.1.4 There shall be no valve or other restrictions within the controller ahead of the pressure-sensing device.

10.5.2.1.5 This pressure-sensing device shall be responsive to water pressure in the fire protection system.

10.5.2.1.6 The pressure-sensing device shall be capable of withstanding a momentary surge pressure of 400 psi (27.6 bar) or 133 percent of fire pump controller rated operating pressure, whichever is higher, without losing its accuracy.

10.5.2.1.7 Suitable provision shall be made for relieving pressure to the pressure-sensing device to allow testing of the operation of the controller and the pumping unit. [See Figure A.4.32(a) and Figure A.4.32(b).]

10.5.2.1.8 Water pressure control shall be in accordance with 10.5.2.1.8.1 through 10.5.2.1.8.6.

10.5.2.1.8.1 Pressure -sensing element of the pressure-sensing device at the low adjustment setting shall initiate pump starting sequence (if pump is not already in operation).

10.5.2.1.8.2* A pressure-recording device shall record the pressure in each fire pump controller pressure-sensing line at the input to the controller.

10.5.2.1.8.3 The pressure recorder shall be listed as part of the controller or shall be a separately listed unit installed to sense the pressure at the input of the controller.

10.5.2.1.8.4 The recorder shall be capable of storing events for at least 7 days.

10.5.2.1.8.5 The pressure-sensing element of the recorder shall be capable of withstanding a momentary surge pressure of at least 400 psi (27.6 bar) or 133 percent of fire pump controller rated operating pressure, whichever is greater, without losing its accuracy.

10.5.2.1.8.6 For variable speed pressure limiting control, a ½ in. (12.7 mm) nominal size inside diameter pressure line shall be connected to the discharge piping at a point recommended by the variable speed control manufacturer. The connection shall be between the discharge check valve and the discharge control valve.

10.5.2.1.8.7 Access to the recorder data shall not require opening the controller nor require taking the controller out of service.

10.5.2.2 Nonpressure Switch-Actuated Automatic Controller.

10.5.2.2.1 Nonpressure switch-actuated automatic fire pump controllers shall commence the controller's starting sequence by the automatic opening of a remote contact(s).

10.5.2.2.2 The pressure switch shall not be required.

10.5.2.2.3 There shall be no means capable of stopping the fire pump motor except those on the fire pump controller.

10.5.2.3 Fire Protection Equipment Control.

10.5.2.3.1 Where the pump supplies special water control equipment (deluge valves, dry pipe valves, etc.), it shall be permitted to start the motor before the pressure-actuated switch(es) would do so.

10.5.2.3.2 Under such conditions the controller shall be equipped to start the motor upon operation of the fire protection equipment.

10.5.2.3.3 Starting of the motor shall be initiated by the opening of the control circuit loop containing this fire protection equipment.

10.5.2.4 Manual Electric Control at Remote Station.

10.5.2.4.1 Where additional control stations for causing nonautomatic continuous operation of the pumping unit, independent of the pressure-actuated switch, are provided at locations remote from the controller, such stations shall not be operable to stop the motor, except as permitted by 10.5.2.4.2.

10.5.2.4.2 A remote momentary station shall be permitted to include a remote stop as long as the remote station is installed within sight of the fire pump controller.