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NFPA 20 Centrifugal Fire Pumps 1990 Edition

National Fire Protection Association 1 Batterymarch Park, Quincy, MA 02269-9101

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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Errata

NFPA 20

Installation of Centrifugal Fire Pumps

1990 Edition

Reference: Table 2-19, 7-1.1.1, A-7.1.1.1(a), A-7.1.1.1(b)

The Committee on Fire Pumps notes the following errors in the 1990 edition of the *Standard for the Installation of Centrifugal Fire Pumps*, NFPA 20:

1. In Table 2-19, change the word "Maximum" to "Minimum" in the table heading.

2. In 7-1.1.1 delete the word "assembly" from the first sentence of item (a). Place an asterisk after the numerical heading for this paragraph.

3. Add the following sections to the Appendix:

A-7-1.1.1(a) Suitable for use means that the controller and transfer switch have been prototype tested and have demonstrated by these tests their short circuit withstandability and interrupting capacity at the stated magnitude of short circuit current and voltage available at their line terminals (see ANSI/UL 509 and ANSI/UL 1008).

A-7-1.1.1(b) After the controller and transfer switch have been subjected to a high fault current, they may not be suitable for further use without inspection and/or repair. Refer to National Electrical Manufacturers Association Publication ICS 2.2-1983, *Maintenance of Motor Controllers After a Fault Condition.*

Issue Date: May 4, 1990

Errata

NFPA 20

Installation of Centrifugal Fire Pumps

1990 Edition

Reference: 7-8.2.5 through 7-8.2.16

The Committee on Fire Pumps notes the following errors in the 1990 edition of *Standard for the Installation of Centrifugal Fire Pumps*, NFPA 20:

1. Insert the following paragraphs and renumber the current paragraphs as shown:

7-8.2.5 The automatic transfer switch shall have a horsepower rating at least equal to the motor horsepower or, when rated in amperes, shall have an ampere rating not less that 115 percent of the motor full-load current and also suitable for switching the motor locked rotor current.

7-8.2.6 When the automatic transfer switch consists of a self-contained switching assembly, such assembly shall be electrically operated and mechanically held.

Renumber existing paragraph	as new paragraph
7-8.2.5	7-8.2.7
7-8.2.6	7-8.2.8
7-8.2.7	7-8.2.9
7-8.2.8	7-8.2.10
7-8.2.9	7-8.2.11
7-8.2.10	7-8.2.12
7-8.2.11	7-8.2.13
7-8.2.12	7-8.2.14
7-8.2.13	7-8.2.15
7-8.2.14	7-8.2.16
7-8.2.15	7-8.2.17
7-8.2.16	7-8.2.18

Issue Date: July 12, 1990

Errata

NFPA 20

Installation of Centrifugal Fire Pumps

1990 Edition

Reference: 3-1.1, Figure A-3-2.1

The Committee on Fire Pumps notes the following errors in the 1990 edition of the *Standard for the Installation of Centrifugal Fire Pumps*, NFPA 20:

1. Revise 3-1.1 to read:

3-1.1 Types. Horizontal pumps shall be of the split-case, end-suction, or in-line design. Single stage end-suction and in-line pumps shall be limited to capacities under 500 gpm (1892 L/min).

2. Replace Figure A-3-2.1, Pump Characteristics, with the following figure:

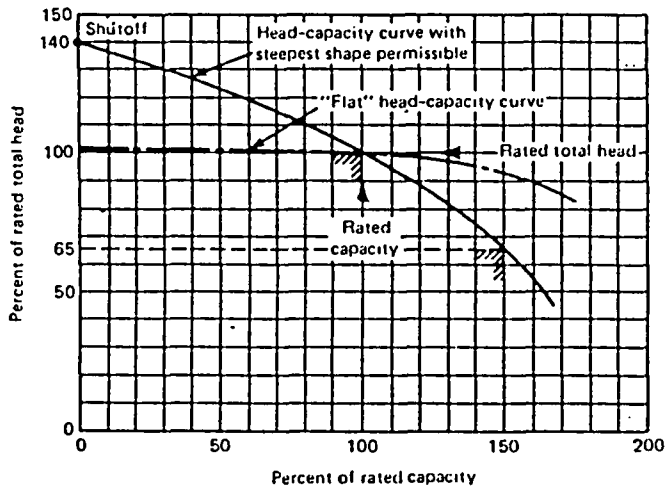

Figure A-3-2.1 Pump Characteristics Curves.

Issue Date: March 19, 1990

NFPA 20

Standard for the Installation of Centrifugal Fire Pumps

1990 Edition

This edition of NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*, was prepared by the Technical Committee on Fire Pumps, released by the Correlating Committee on Water Extinguishing Systems, and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 13-15, 1989, in Seattle, WA. It was issued by the Standards Council on January 12, 1990, with an effective date of February 5, 1990, and supersedes all previous editions.

The 1990 edition of this document has been approved by the American National Standards Institute.

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

Origin and Development of NFPA 20

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

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

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

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

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

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

The 1990 edition includes revised information for electric motors and fire pump controller equipment. Other changes will allow the document to conform more closely to the NFPA *Style Manual.*

NOTICE

Following release by the NFPA Standards Council of this 1990 edition of NFPA 20, *Standard for Installation of Centrifugal Fire Pumps*, an appeal was filed with the NFPA Board of Directors.

The appeal requests that the conductors feeding fire pumps systems be changed from feeder circuit conductors to service conductors as accepted in the Technical Committee Reports for NFPA 20, 1990 edition.

NFPA will announce the disposition of this appeal when it has been determined. Anyone wishing to receive automatically a copy of the disposition of the appeal should notify in writing the Secretary, Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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

Contents

NFPA 20

Standard for the Installation of

Centrifugal Fire Pumps

1990 Edition

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

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

Chapter 1 Introduction

1-1 Scope. This standard deals with the selection and installation of pumps supplying water for private fire protection. Items considered include water supplies, suction, discharge, and auxiliary equipment; power supplies, electric drive and control; internal combustion engine drive and control; steam turbine drive and control; acceptance tests, operation, and maintenance. This standard does not contain system water supply capacity and pressure requirements. (*See A-2-1.1.*)

1-2 Purpose.

1-2.1 The purpose of this standard is to provide a reasonable degree of protection for life and property from fire through installation requirements for centrifugal fire pumps based upon sound engineering principles, test data, and field experience. It includes single stage and multistage pumps of horizontal or vertical shaft design. Guidelines are established for the design, installation, and maintenance of these pumps, pump drivers, and associated equipment. The standard endeavors to continue the excellent record that has been established by centrifugal pump installations and to meet the needs of changing technology. Nothing in this standard is intended to restrict new technologies or alternate arrangements providing the level of safety prescribed by the standard is not lowered.

1-2.2 Existing Installations. Where existing pump installations meet the provisions of the standard in effect at the time of purchase, they may remain in use provided they do not constitute a distinct hazard to life or adjoining property.

1-3 Other Pumps. Pumps other than those specified in this standard, and having different design features, may be installed when such pumps are listed by a testing laboratory. They shall be limited to capacities of less than 500 gpm (1892 L/min).

1-4* Approval Required.

1-4.1 Centrifugal fire pumps shall be selected based on the conditions under which they are to be installed and used.

1-4.2 The pump manufacturer or its designated representative shall be given complete information concerning the water and power supply characteristics.

1-4.3 A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and water supply conditions shall be prepared for approval. Each pump, driver, controlling equipment, power supply and arrangement, and water supply shall be approved by the authority having jurisdiction for the specific field conditions encountered.

1-5 Unit Performance.

1-5.1* The unit, consisting of a pump, driver, and controller, shall perform in compliance with this standard as an entire unit when installed or when components have been replaced.

1-5.2 The complete unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. (*See Section 11-2.*)

1-6 Certified Shop Test. Certified shop test curves showing head-capacity and brake-horsepower of the pump shall be furnished by the manufacturer to the purchaser. The purchaser shall furnish this data to the authority having jurisdiction.

1-7 Definitions.

1-7.1 Controllers.

1-7.1.1 Controller. The cabinet, motor starter, circuit breaker and disconnect switch, and other control devices for the control of electric motors and internal combustion engine driven pumps.

1-7.1.2 Isolating Switch. A switch intended for isolating an electric circuit from its source of power.

1-7.1.3 Disconnecting Means. A device, group of devices, or other arrangement (such as a circuit breaker or disconnecting switches) whereby the conductors of a circuit can be disconnected from their source of supply.

1-7.2 Transfer Switches.

1-7.2.1 Automatic Transfer Switch. An automatic transfer switch is self-acting equipment for transferring one or more load conductor connections from one power source to another.

1-7.2.2 Manual Transfer Switch. A manual transfer switch is a switch, operated by direct manpower, for transferring one or more load conductor connections from one power source to another.

1-7.3 Electric Motors. Electric motors are classified according to mechanical protection and methods of cooling.

1-7.3.1 Open Motor. An open motor is one having ventilating openings that permit passage of external cooling air over and around the windings of the motor. The term "open motor," when applied to large apparatus without qualification, designates a motor having no restriction to ventilation other than that necessitated by mechanical construction.

1-7.3.2 Dripproof Motor. A dripproof motor is 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.

1-7.3.3 Guarded Motor. A guarded motor is 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.

1-7.3.4 Dripproof Guarded Motor. A dripproof guarded motor is a dripproof machine whose ventilating openings are guarded in accordance with 1-7.3.2.

1-7.3.5 Service Factor. The service factor of an a-c motor is a multiplier that, when applied to the rated horsepower, indicates a permissible horsepower loading that may be carried at the rated voltage, frequency, and temperature. The multiplier 1.15 indicates that the motor may be overloaded to 1.15 times the rated horsepower.

1-7.3.6 Totally Enclosed Motor. A totally enclosed motor is one so enclosed 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.

1-7.3.7 Totally Enclosed Nonventilated Motor. A totally enclosed nonventilated motor is a totally enclosed motor that is not equipped for cooling by means external to the enclosing parts.

1-7.3.8 Totally Enclosed Fan-Cooled Motor. A totally enclosed fan-cooled motor is 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.

1-7.3.9 Explosionproof Motor. An explosionproof motor is a totally enclosed motor whose enclosure is designed and constructed to withstand an explosion of a specified gas or vapor that may 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 may occur within the motor casing.

1-7.3.10 Dust-Ignition-Proof. A dust-ignition-proof motor is 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.

1-7.4 Electric Supply.

1-7.4.1 Fire Pump Branch Circuit. That portion of the wiring system between the motor and the final overcurrent device protecting the circuit and the motor. (*See Article 430, Section B, NFPA 70, National Electrical Code®.*)

1-7.4.2 Feeder. The circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device. (*See Article 100, NFPA 70, National Electrical Code.*)

1-7.4.3 Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served. (*See Article 100, NFPA 70, National Electrical Code.*)

1-7.4.4 Service Equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply. (*See Article 100, NFPA 70, National Electrical Code.*)

1-7.5 Engines.

1-7.5.1 Internal Combustion Engine. Any engine in which the working medium consists of the products of combustion of the air and fuel supplied. This combustion usually is effected within the working cylinder but may take place in an external chamber.

1-7.5.2 Diesel Engine. An internal combustion engine in which the fuel is ignited entirely by the heat resulting from the compression of the air supplied for combustion. The oil-diesel engine, which operates on fuel oil injected after compression is practically completed, is the type usually used as a fire pump driver.

1-7.6* Head.

1-7.6.1 Head. The unit for measuring head shall be the foot (m). The relation between a pressure expressed in pounds per square inch (bars) and a pressure expressed in feet (m) of head is:

$$\text{Head in Feet} = \frac{\text{Pressure in psi}}{0.433 \text{ s.g.}}$$

$$\text{Head in Meters} = \frac{\text{Pressure in bars}}{0.098 \text{ s.g.}}$$

1-7.6.2 Velocity Head (Symbol h_v). The velocity head shall be figured from the average velocity (v) obtained by dividing the flow in cubic feet per second (m^3/s) by the actual area of pipe cross section in square feet (m^2) and determined at the point of the gage connection.

Velocity head is expressed by the formula:

$$H_v = \frac{v^2}{2g}$$

Where g = the acceleration due to gravity and is 32.17 ft per second per second (9.807 m/s^2) at sea level and 45 degrees latitude.

V = Velocity in the pipe in feet per second (m/s).

1-7.6.3 Flooded Suction. 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.

1-7.6.4 Total Suction Lift (Symbol h_l). Suction lift exists where the total suction head is below atmospheric pressure. Total suction lift, as determined on test, is the reading of a liquid manometer at the suction nozzle of the pump, converted to feet of liquid, and referred to datum, minus the velocity head at the point of gage attachment.

1-7.6.5 Total Suction Head (Symbol h_s). Suction head exists when the total suction head is above atmospheric pressure. Total suction head, as determined on test, is the reading of a gage at the suction of the pump, converted to feet of liquid, and referred to datum, plus the velocity head at the point of gage attachment.

1-7.6.6 Total Discharge Head (Symbol h_d). Total discharge head is the reading of a pressure gage at the discharge of the pump, converted to feet of liquid, and referred to datum, plus the velocity head at the point of gage attachment.

1-7.6.7* Total Head (Symbol H), Horizontal Pumps. Total head is the measure of the work increase per pound (kg) of liquid, imparted to the liquid by the pump, and is 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.

1-7.6.8* Total Head (Symbol H), Vertical Turbine Pumps. Total head (H) is the distance from the pumping water level to the center of the discharge gage, plus the total discharge head.

1-7.6.9 Total Rated Head. The total head, defined above, developed at rated capacity and rated speed for either a horizontal splitcase or a vertical shaft turbine-type pump.

1-7.6.10 Net Positive Suction Head — NPSH (Symbol h_{sv}). The net positive suction head is the total suction head in feet (m) of liquid absolute, determined at the suction nozzle, and referred to datum less the vapor pressure of the liquid in feet (m) absolute.

1-7.7 Pumps.

1-7.7.1 Centrifugal Pump. A pump in which the pressure is developed principally by the action of centrifugal force.

1-7.7.2 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.

1-7.7.3 In Line Pump. A centrifugal pump whose drive unit is supported by the pump having it's suction and discharge flanges on approximately the same centerline.

1-7.7.4 Fire Pump Unit. An assembled unit consisting of a fire pump, driver, controller, and accessories.

1-7.7.5 Horizontal Pump. A pump with the shaft normally in a horizontal position.

1-7.7.6 Horizontal Split-case Pump. A centrifugal pump characterized by a housing that is split parallel to the shaft.

1-7.7.7 Vertical Shaft Turbine Pump. A centrifugal pump with one or more impellers discharging into one or more bowls and a vertical eductor or column pipe used to connect the bowl(s) to the discharge head on which the pump driver is mounted.

1-7.7.8* Can Pump. A vertical shaft turbine-type pump in a can (suction vessel) for installation in a pipeline to raise water pressure.

1-7.7.9 A booster pump is a fire pump that takes suction from a public service main or private-use water system for the purpose of increasing the effective water pressure.

1-7.7.10 Corrosion-Resistant Material. Corrosion-resistant materials are brass, copper, monel, stainless steel, or other equivalent corrosion-resistant materials.

1-7.8 Water Supply for Vertical Shaft Turbine-type Pump.

1-7.8.1 Aquifer. An underground formation that contains sufficient saturated permeable material to yield significant quantities of water.

1-7.8.2 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.

1-7.8.3 Wet Pit. A timber, concrete, or masonry enclosure having a screened inlet kept partially filled with water by an open body of water such as a pond, lake, or stream.

1-7.8.4 Ground Water. That water that is available from a well, driven into water-bearing subsurface strata (aquifer).

1-7.8.5 Static Water Level. The level, with respect to the pump, of the body of water from which it takes suction, when the pump is not in operation. For vertical shaft turbine-type pumps, the distance to the water level is measured vertically from the horizontal centerline of the discharge head or tee.

1-7.8.6 Pumping Water Level. The level, with respect to the pump, of the body of water from which it takes suction, when the pump is in operation. Measurements are made the same as in 1-7.8.5.

1-7.8.7 Draw-Down. The vertical difference between the pumping water level and the static water level.

1-7.9 Official NFPA Definitions.

1-7.9.1 Approved. Acceptable to the authority having jurisdiction.

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

1-7.9.2 Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

1-7.9.3 Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

1-7.9.4 Shall. Indicates a mandatory requirement.

1-7.9.5 Should. Indicates a recommendation or that which is advised but not required.

1-7.9.6 Standard. A document containing only mandatory provisions using the word "shall" to indicate requirements. Explanatory material may be included only in the form of "fine print" notes, in footnotes, or in an appendix.

1-7.10 Additional Definitions. Additional applicable definitions may be found in the latest edition of *Hydraulic Institute Standards for Centrifugal, Rotary, and Reciprocating Pumps.*

1-8 Maximum Pump Brake Horsepower. The maximum brake horsepower required to drive the pump at rated speed. The pump manufacturer determines this by shop test under expected suction and discharge conditions. Actual field conditions may vary from shop conditions.

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

Table 1-9

Name of Unit	Unit Symbol	Conversion Factor
meter	m	1 ft = 0.3048 m
millimeter	mm	1 in. = 25.4 mm
liter	L	1 gal = 3.785 L
cubic decimeter	dm^3	1 gal = 3.785 dm^3
cubic meter	m^3	1 ft^3 = 0.0283 m^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

For additional conversions and information, see ASTM E380.

1-9.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate.

1-9.2 The conversion procedure for the SI units has been to multiply the quantity by the conversion factor and then round the result to the approximate number of significant digits.

Chapter 2 General

2-1 Water Supplies.

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

2-1.2* Sources. Any source of water that is adequate in quality and quantity may provide the supply for fire pumps. Where the water supply is from a public service main, pump operation shall not reduce the suction head below the pressure allowed by the local regulatory authority.

2-1.3 The minimum water level of a well or wet pit shall be determined by pumping at not less than 150 percent of the fire pump rated capacity.

2-1.4* A stored supply shall be sufficient to meet the demand placed upon it for the expected duration, and a reliable method of replenishing the supply shall be provided.

2-1.5 The head available from a water supply shall be figured on the basis of a flow of 150 percent of rated capacity of the fire pump. This head shall be as indicated by a flow test.

2-2 Listed Pumps.

2-2.1 Centrifugal fire pumps shall be listed for fire protection service.

2-2.2 Except for installations made prior to adoption of the 1974 edition of this standard, dual drive pump units shall not be used.

2-3 Rated Pump Capacities.

2-3.1* Fire pumps shall have the following rated capacities in gpm and L/min and are rated at net pressures of 40 psi (2.7 bars) or more. Pumps for ratings over 5000 gpm are subject to individual review by either the authority having jurisdiction or a listing laboratory.

gpm	L/min	gpm	L/min	gpm	L/min
25	95	400	1514	2000	7570
50	189	450	1703	2500	9462
100	379	500	1892	3000	11 355
150	568	750	2839	3500	13 247
200	757	1000	3785	4000	15 140
250	946	1250	4731	4500	17 032
300	1136	1500	5677	5000	18 925

2-4 Nameplate. Pumps shall be provided with a nameplate.

2-5 Pressure Gages.

2-5.1 A pressure gage having a dial not less than 3½ in. (89 mm) in diameter shall be connected near the discharge casting with a ¼-in. gage valve. The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than 200 psi (13.8 bars). The face of the dial shall read in pounds per square inch or bars or both with the manufacturer's standard graduations.

2-5.2* A compound pressure and vacuum gage having a dial not less than 3½ in. (89 mm) in diameter shall be connected to the suction pipe near the pump with a ¼-in. gage valve.

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

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

2-6 Circulation Relief Valve. Each pump shall be provided with an automatic relief valve set below the shut off pressure at minimum expected suction pressure. It shall provide circulation of sufficient water to prevent the pump from overheating when operating with no discharge. Provision shall be made for a discharge to a drain.

Min. size of automatic relief valve shall be ¾ in. (19.0 mm) for pumps with a rated capacity not exceeding 2500 gpm (9462 L/min), 1 in. (25.4 mm) for pumps with a rated capacity of 3000 to 5000 gpm (11 355 to 18 925 L/min).

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

2-7* Equipment Protection.

2-7.1* The fire pump, driver, and controller shall be protected against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism, and other adverse conditions.

2-7.2 Suitable means shall be provided for maintaining the temperature of a pump room or pump house, where required, above 40°F (5°C).

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

2-7.3 Artificial light shall be provided in a pump room or pump house.

2-7.4 Emergency lighting shall be provided by fixed or portable battery operated lights, including flashlights. Emergency lights shall not be connected to an engine starting battery.

2-7.5 Provision shall be made for ventilation of a pump room or pump house.

2-7.6* Floors shall be pitched for adequate drainage of escaping water or fuel away from critical equipment such as the pump, driver, controller, fuel tank, etc. The pump room or pump house shall be provided with a floor drain that will discharge to a frost-free location.

2-7.7 Coupling Guards. Coupling guards shall be provided to prevent rotating elements from causing injury to personnel.

2-8 Pipe and Fittings.

2-8.1* Steel pipe shall be used aboveground except for connection to underground suction and underground discharge piping. To prevent tuberculation, suction pipe shall be galvanized or painted on the inside prior to installation, with a paint recommended for submerged surfaces. Thick bituminous linings shall not be used.

2-8.2 Sections of steel piping shall be joined by means of screwed, flanged (flanges welded to pipe are preferred), mechanical grooved joints, or other approved fittings.

Exception: Slip-type fittings may be used when installed as required by 2-9.6(f) and when the piping is mechanically secured to prevent slippage.

2-8.3 All provisions for welded pipe shall be in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*

2-8.4 Torch cutting or welding in the pump house shall not be permitted as a means of modifying or repairing pump house piping.

2-9 Suction Pipe and Fittings.

2-9.1* Suction pipe shall have a pressure rating not less than that required for yard piping. It shall be installed and tested in accordance with NFPA 24, *Standard for Private Fire Service Mains and Their Appurtenances.*

2-9.2 Cement asbestos suction pipe shall be acceptable, except aboveground, when the pump takes suction under a positive head at all times.

2-9.3 Multiple Pumps. Where a single suction pipe supplies more than one pump, the suction piping layout at the pumps shall be arranged so that each pump will receive its proportional supply.

2-9.4* Suction Size. The size of the suction pipe for single or multiple pumps or both (arranged to operate simultaneously) shall be such that with all pumps operating at 150 percent of rated capacity, the gage pressure at the pump suction flange shall be 0 psig (0 bars) or higher. The suction pipe shall not be less than that specified in Table 2-19.

2-9.5* Pumps with Bypass. When the suction supply is under sufficient pressure to be of material value without the pump, the pump shall be installed with a bypass. (*See Figure A-2-9.5.*)

2-9.6* Installation.

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

(b) Suction pipes shall be installed below the frost line or in frostproof casing. Where piping enters streams, ponds, or reservoirs, special attention shall be given to prevent freezing either underground or underwater.

(c) Elbows with a centerline plane parallel to a horizontal split-case pump shaft shall be avoided.

(d) When the suction pipe and pump suction flange are not of the same size, they shall be connected with an eccentric tapered reducer in such a way as to avoid air pockets.

(e) All pump suction pipes, except short lengths between suction tanks and pumps, shall be hydrostatically tested in accordance with tests for yard mains given in NFPA 24, *Standard for Private Fire Service Mains and Their Appurtenances*, Section 8-9.3.

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

2-9.7* Control Valve. A listed O.S. & Y. gate valve shall be installed in the suction pipe. A butterfly valve shall not be installed in the suction pipe.

2-9.8* Suction Screening. Where the water supply is obtained from an open source, such as a pond or wet pit, the passage of materials which might clog the pump shall be obstructed. Double removable intake screens shall be provided at the suction intake. These screens shall have (below minimum water level) an effective net area of openings of 1 sq in. (645 mm) for each gpm (3.785 L/min) at 150 percent of rated pump capacity. Screens shall be so arranged that they can be cleaned or repaired without disturbing the suction pipe. A brass, copper, monel, stainless steel, or other equivalent corrosion-resistant metallic material wire screen of ½ in. (12.7 mm) mesh and No. 10 B. & S. gage wire shall be secured to a metal frame sliding vertically at the entrance to the intake. The overall area of this particular screen is 1.6 times the net screen opening area. (*See screen details in Figure A-4-2.2.2.*)

2-9.9* Devices in Suction Piping.

(a) No device which will restrict the starting, stopping, or discharge of a fire pump or pump driver shall be installed in the suction piping.

Exception: Except as specified in 2-9.7.

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

2-9.10 Vortex Plate. For pump(s) taking suction from a stored water supply, a vortex plate shall be installed at the entrance to the suction pipe. (*For example, see Figure A-3-3.1 and the Hydraulic Institute Standards.*)

2-10 Discharge Pipe and Fittings.

2-10.1 The discharge components shall consist of pipe, valves, and fittings extending from the pump discharge flange to the system side of the discharge valve.

2-10.2 The pressure rating of the discharge components shall be adequate for the maximum working pressure but not less than the rating of the fire protection system. Steel pipe with flanges (flanges welded to the pipe are preferred), screwed or mechanical grooved joints shall be used aboveground. All pump discharge pipe shall be hydrostatically tested in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 24, *Standard for Private Fire Service Mains and Their Appurtenances.*

2-10.3* The size of pump discharge pipe and fittings shall be not less than that given in Table 2-19.

2-10.4* A listed check valve shall be installed in the pump discharge assembly.

2-10.5 A listed indicating gate or butterfly valve shall be installed on the fire protection system side of the check valve.

2-11 Valve Supervision. The suction control valve (if provided), discharge control valve, and by-pass control valve (if provided) shall be supervised open by one of the following methods:

(a) Central station, proprietary, or remote station signaling service.

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

(c) Locking valves open.

(d) Sealing of valves and approved weekly recorded inspection when valves are located within fenced enclosures under the control of the owner.

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

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

2-12.1* A clearance of not less than 1 in. (25.4 mm) shall be provided around pipes which pass through walls or floors.

2-13 Relief Valve.

2-13.1 Pumps connected to adjustable-speed drivers shall be equipped with a listed relief valve. Where pumps are driven by constant-speed motors and the pump shutoff pressure plus the static suction pressure exceeds the pressure for which the system components are rated, relief valves are required.

Exception: Pumps supplying only standpipe systems do not generally require relief valves.

2-13.2 The relief valve shall be set to prevent pressure on the fire protection system greater than it can withstand.

2-13.3 The relief valve size shall not be less than that given in Table 2-19. (*Refer also to 2-13.9 and A-2-13.9 for conditions affecting size.*)

2-13.4 The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

2-13.5 Pressure relief valves are of two types: the spring loaded and the pilot operated diaphragm type.

2-13.5.1 Pilot operated pressure relief valves, when attached to vertical shaft turbine pumps, shall be arranged to prevent relieving of water at water pressures less than the pressure relief setting of the valve.

2-13.6* The relief valve shall discharge into an open pipe or into a cone or funnel secured to the outlet of the valve. Water discharge from the relief valve shall be readily visible or easily detectable by the pump operator. Splashing of water into the pump room shall be avoided. If a closed-type cone is used, it shall be provided with means for detecting motion of water through the cone. If the relief valve is provided with means for detecting motion (flow) of water through the valve, then cones or funnels at its outlet are not required.

2-13.7 The relief valve shall not be piped to the pump suction or supply connection.

Exception: If no other adequate or acceptable means of water disposal is available, this arrangement shall be acceptable. When the relief discharge is piped to the pump suction or supply connection, a means for detecting motion (flow) shall be installed in the relief valve discharge pipe.

2-13.8 The relief valve discharge pipe from an open cone shall be of a size not less than that given in Table 2-19. If the pipe employs more than one elbow, the next larger pipe size shall be used.

2-13.9* When the relief valve must be piped back to the source of supply, the relief valve and piping shall have sufficient capacity to prevent pressure from exceeding that for which system components are rated.

2-13.10 When 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. If this discharge enters the reservoir below minimum water level, there is not likely to be an air problem. If it enters over the top of the reservoir, the air problem is reduced by extending the discharge to below the normal water level.

2-13.11 A shutoff valve shall not be installed in the relief valve supply or discharge piping.

2-14 Water Measuring Devices.

2-14.1 General.

2-14.1.1 A water measuring device shall be provided to test the pump. A fire pump installation and fire protection system(s) shall have the ability to test the pump and the suction supply at the maximum flow available from the fire pump.

2-14.1.2* Where water usage or discharge is not permitted for the duration of the test specified in Chapter 11, the outlet shall be used to test the pump and suction supply and determine that the system is operating in accordance with the design. The flow shall continue until flow has stabilized (*see 11-2.6.3*).

2-14.2 Meters.

2-14.2.1* Metering devices or fixed nozzles for pump testing shall be listed. They shall be capable of water flow of not less than 175 percent of pump rated capacity.

2-14.2.2 All of the meter system piping shall be sized as specified by the meter manufacturer but not less than the meter device sizes shown in Table 2-19.

2-14.2.3 The minimum size meter for a given pump capacity may be used where the meter system piping does not exceed 100 ft (30 m) equivalent length. Where meter system piping exceeds 100 ft (30 m) (length of straight pipe plus equivalent length in fittings, elevation, and loss through meter), the next larger size of piping shall be used to minimize friction loss. The primary element shall be suitable for that pipe size and pump rating. The readout instrument shall be sized for the pump rated capacity. (*See Table 2-19.*)

2-14.3 Hose Valves.

2-14.3.1* Hose valves shall be listed. The number and size of hose valves used for pump testing shall be as specified in Table 2-19. Hose valves shall be mounted on a hose valve header and supply piping shall be sized per Table 2-19.

2-14.3.2 Hose valve(s) shall have the NH standard external thread, for the valve size specified, as specified in NFPA 1963, *Standard for Screw Threads and Gaskets for Fire Hose Connections.*

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

2-14.3.3 Where the hose valve header is located outside, or at a distance from the pump, and there is danger of freezing, a listed indicating or butterfly gate valve and drain valve or ball drip shall be located in the pipe line to the hose valve header. The valve shall be at a point in the line close to the pump. (*See Figure A-3-3.1.*)

2-14.3.4 When the pipe between the hose valve header and connection to the pump discharge pipe is over 15 ft (4.5 m) in length, the next larger pipe size shall be used.

2-15 Power Supply Dependability.

2-15.1 Electric Supply. Careful consideration shall be given in each case to the dependability of the electric supply system and the wiring system. This shall include the possible effect of fire on transmission lines either in the property or in adjoining buildings that might threaten the property.

2-15.2 Steam Supply. Careful consideration shall be given in each case to the dependability of the steam supply and the steam supply system. This shall include the possible effect of fire on transmission piping either in the property or in adjoining buildings that might threaten the property.

2-16 Shop Tests.

2-16.1 Each individual pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with specifications.

2-16.2 Before shipment from the factory, each pump shall be hydrostatically tested by the manufacturer for a period of time not less than 5 minutes. The test pressure shall not be less than 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 bars). Pump casings shall be essentially tight at the test pressure. During the test, no objectionable leakage shall occur at any joint. In the case of vertical turbine-type pumps, both the discharge casting and pump bowl assembly shall be tested.

2-17* Pump Shaft Rotation. Pump shaft rotation shall be determined and correctly specified when ordering fire pumps and equipment involving that rotation.

2-18* Alarms. Various sections of this standard specify alarms to call attention to improper conditions that may exist in the complete fire pump equipment.

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

2-19.1 Pressure maintenance pumps shall have rated capacities not less than any normal leakage rate. They shall have discharge pressure sufficient to maintain the desired fire protection system pressure.

2-19.2 A check valve shall be installed in the discharge pipe.

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

2-19.4* Where a centrifugal-type pressure maintenance pump has a shutoff pressure exceeding the working pressure rating of the fire protection equipment, or where a turbine vane (peripheral) or a positive displacement (reciprocating or rotary) type of pump is used, a suitable relief valve shall be installed on the pump discharge to prevent damage to the fire protection system.

2-19.5 A fire pump shall not be used as a pressure maintenance pump.

2-20 Summary of Fire Pump Data. (*See Table 2-19.*)

Table 2-19 Summary of Fire Pump Data

	Maximum Pipe Sizes (Nominal)						
Pump Rating gpm L/min	Suction in.*	Discharge in.*	Relief Valve in.	Relief Valve Discharge in.	Meter Device in.	Number and Size of Hose Valves in.	Hose Header Supply in.
25 (95)	1	1	¾	1	1¼	1 – 1½	1
50 (189)	1½	1¼	1¼	1½	2	1 – 1½	1¼
100 (379)	2	2	1½	2	2½	2 – 1½	2
150 (568)	2½	2½	2	2½	3	1 – 2½	2½
200 (757)	3	3	2	2½	3	1 – 2½	2½
250 (946)	3½	3	2	2½	3½	1 – 2½	3
300 (1136)	4	4	2½	3½	3½	1 – 2½	3
400 (1514)	4	4	3	5	4	2 – 2½	4
450 (1703)	5	5	3	5	4	2 – 2½	4
500 (1892)	5	5	3	5	5	2 – 2½	4
750 (2839)	6	6	4	6	5	3 – 2½	6
1000 (3785)	8	6	4	8	6	4 – 2½	6
1250 (4731)	8	8	6	8	6	6 – 2½	8
1500 (5677)	8	8	6	8	8	6 – 2½	8
2000 (7570)	10	10	6	10	8	6 – 2½	8
2500 (9462)	10	10	6	10	8	8 – 2½	10
3000 (11 355)	12	12	8	12	8	12 – 2½	10
3500 (13 247)	12	12	8	12	10	12 – 2½	12
4000 (15 140)	14	12	8	14	10	16 – 2½	12
4500 (17 032)	16	14	8	14	10	16 – 2½	12
5000 (18 925)	16	14	8	14	10	20 – 2½	12

*Actual pump flange may be less than pipe size.

Chapter 3 Horizontal Pumps

3-1 General.

3-1.1 Types. Horizontal pumps shall be of the split-case, end-suction, or in-line design. Single stage and in-line pumps shall be limited to capacities under 500 gpm (1892 L/min).

3-1.2 Application. The horizontal centrifugal pump in horizontal or vertical position shall not be used where a static suction lift is involved.

3-2 Factory and Field Performance.

3-2.1* Characteristics. Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shutoff head shall not exceed 140 percent of rated head for any type pump. (*See Figure A-3-2.1.*)

3-2.2 Upon completion of the entire fire pump installation, an acceptance test shall be conducted in accordance with the provisions of this standard.

3-3 Fittings.

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

(a) Automatic air release.

(b) Circulation relief valve.

(c) Pressure gages.

3-3.2 Where necessary, the following fittings shall be provided (*see Figure A-3-3.1*).

(a) Eccentric tapered reducer at suction inlet.

(b) Hose valve manifold with hose valves.

(c) Flow measuring device.

(d) Relief valve and discharge cone.

3-3.3 Automatic Air Release. Pumps which are automatically controlled shall be provided with a listed float-operated air release not less than ½ in. in size, to automatically release air from the pump.

3-4 Foundation and Setting.

3-4.1 The pump and driver shall be mounted on a common base plate and connected by a flexible coupling.

3-4.2 The base plate shall be securely attached to a solid foundation in such a way that proper pump and driver shaft alignment will be assured.

3-4.3* The foundation shall be sufficiently substantial to form a permanent and rigid support for the base plate.

3-4.4 The base plate, with pump and driver mounted on it, shall be set level on the foundation.

3-5* Alignment. Pumps and drivers shall be aligned in accordance with the latest edition of *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.* (*See A-3-5.*)

Chapter 4 Vertical Shaft Turbine-type Pumps

4-1* General.

4-1.1* Suitability. The deep-well, turbine-type pump is a vertical shaft centrifugal pump with rotating impellers suspended from the pump head by a column pipe that also serves as a support for the shaft and bearings. It is particularly suitable for fire pump service when the water source is located below ground and where it would be difficult to install any other type of pump below the minimum water level. It was originally designed for installation in drilled wells, but may also be used to lift water from lakes, streams, open swamps and other subsurface sources. Both oil-lubricated enclosed-line-shaft and water-lubricated open-line-shaft pumps are used. Some health departments object to the use of oil-lubricated pumps; such authorities shall be consulted before proceeding with oil-lubricated design.

4-1.2 Maximum Depth. Fire pumps shall not be installed in a well where the pumping water level exceeds 200 ft (61 m) from the surface of the ground when pumping at 150 percent of rated capacity. In all applications the authority having jurisdiction shall be supplied with data on the draw-down characteristics of the well and the pump performance. The available discharge pressure at the discharge flange of the vertical pump can be determined from this data. (*See Section 1-7 for definitions.*)

4-1.3 Characteristics. Pumps shall furnish not less than 150 percent of rated capacity at a total head of not less than 65 percent of the total rated head. The total shutoff head shall not exceed 140 percent of total rated head on vertical turbine pumps. (*See Figure A-3-2.1.*)

4-2 Water Supply.

4-2.1 Source.

4-2.1.1* The water supply shall be adequate, dependable, and acceptable to the authority having jursidiction.

4-2.1.2* The acceptance of a well as a water supply source shall be dependent upon satisfactory development of the well and establishment of satisfactory aquifer characteristics. (*See Section 1-7 for definitions.*)

4-2.2 Pump Submergence.

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

4-2.2.2* Wet Pit Installations. To provide submergence for priming, the elevation of the second impeller from the bottom of the pump bowl assembly shall be such that it is below the lowest pumping water level in the open body of water

supplying the pit. For pumps with rated capacities of 2000 gpm (7570 L/min) or greater, additional submergence may be required to prevent the formation of vortices and/or provide required NPSH available to prevent excessive cavitation. The required submergence shall be obtained from the pump manufacturer. See the *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*, 13th edition.

4-2.3 Well Construction.

4-2.3.1 It shall be the responsibility of the groundwater supply contractor to perform the necessary groundwater investigation to establish the reliability of the supply, develop a well to produce the required supply, to perform all work and install all equipment in a thorough and workmanlike manner.

4-2.3.2 The vertical turbine-type pump is designed to operate in a vertical position with all parts in correct alignment. The well therefore shall be of ample diameter and sufficiently plumb to receive the pump.

4-2.4 Unconsolidated Formations (Sands and Gravels).

4-2.4.1 All casings shall be of steel of such diameter and installed to such depths as the formation may justify and best meet the conditions. Both inner and outer casing shall have a minimum wall thickness of 0.375 in. (9.5 mm). Inner casing diameter shall be not less than 2 in. (51 mm) larger than the pump bowls.

4-2.4.2 Outer casing shall extend down to approximately the top of the water-bearing formation. The inner casing of lesser diameter and the well screen shall extend as far into the formation as the water-bearing stratum may justify and as best meets the conditions.

4-2.4.3 The well screen is a vital part of the construction and careful attention shall be given to its selection. It shall be the same diameter as the inner casing and of the proper length and percent open area to provide an entrance velocity not exceeding 0.15 ft (46 mm) per second. The screen shall be made of a corrosion- and acid-resistant material, such as stainless steel or monel; monel shall be used where it is anticipated that the chloride content of the well water will exceed 1000 parts per million. The screen shall have adequate strength to resist the external forces that will be applied after it is installed, and to minimize the likelihood of damage during the installation.

4-2.4.4 The bottom of the well screen shall be sealed properly with a plate of the same material as the screen. The sides of the outer casing shall be sealed by the introduction of neat cement placed under pressure from the bottom to the top. Cement shall be allowed to set for a minimum of 48 hours before drilling operations are continued.

4-2.4.5 The immediate area surrounding the well screen not less than 6 in. (152 mm) shall be filled with clean and well-rounded gravel. This gravel will be of such size and quality as will create a gravel filter to ensure sand-free production and a low velocity of water leaving the formation and entering the well.

4-2.4.6 Wells. Wells for fire pumps not exceeding 450 gpm (1703 L/min) developed in unconsolidated formations without an artificial gravel pack (tubular wells) are acceptable sources of water supply for fire pumps not exceeding 450 gpm (1703 L/min). They shall comply with all of the requirements of 4-2.3 and all of 4-2.4 except 4-2.4.4 and 4-2.4.5.

4-2.5* Consolidated Formations. Where the drilling penetrates unconsolidated formations above the rock, surface casing shall be installed, seated in solid rock, and cemented in place.

4-2.6 Developing a Well. Developing a new well and cleaning it of sand or rock particles (not to exceed five parts per million) shall be the responsibility of the groundwater supply contractor. Such development shall be performed with a test pump and not the fire pump. Freedom from sand shall be determined when the test pump is operated at 150 percent of rated capacity of the fire pump for which the well is being prepared.

4-2.7* Test and Inspection of Well. A test to determine the water production of the well shall be made. An acceptable water measuring device such as an orifice, a venturi meter or a calibrated pitot tube shall be used. The test shall be witnessed by a representative of the customer, contractor, and authority having jurisdiction, as required. It shall be continuous for a period of at least 8 hours at 150 percent of the rated capacity of the fire pump, with 15-minute interval readings over the period of the test. The test shall be evaluated with consideration given to the effect of other wells in the vicinity and any possible seasonal variation in the water table at the well site. Test data shall describe the static water level and the pumping water level at 100 and 150 percent of the rated capacity of the fire pump for which the well is being prepared. All existing wells within a 1000-ft (305-m) radius of the fire well shall be monitored throughout the test period.

Table 4-3.2 Pump Column Pipe Weights

Nominal Size (ID) (in.)	Outside Diameter (in.)	Outside Diameter (mm)	Weight per ft (plain ends) (lbs)*	Nominal Size (ID) (in.)	Outside Diameter (in.)	Outside Diameter (mm)	Weight per ft (Plain ends) (lbs)*
6	6.625	168.3	18.97	10	10.75	273.0	31.20
7	7.625	193.7	22.26	12	12.75	323.8	43.77
8	8.625	219.1	24.70	14 OD	14.00	355.6	53.57
9	9.625	244.5	28.33				

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

4-3 Pump.

4-3.1* Head. The pump head shall be either the above-ground or belowground discharge type. It shall be designed to support the driver, pump column, and the oil tube tension nut or packing container. (*See Figure A-4-3.1.*)

4-3.2 Column.

4-3.2.1 The pump column shall be furnished in sections not exceeding a nominal length of 10 ft (3 m), shall be not less than the weight specified in Table 4-3.2, and shall be connected by threaded-sleeve couplings or flanges. The ends of each section of threaded pipe shall be faced parallel and machined with threads to permit the ends to butt so as to form accurate alignment of the pump column. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment.

4-3.2.2 When the static water level exceeds 50 ft (15 m) belowground, oil-lubricated-type pumps shall be used. (*See Figure A-4-1.1.*)

4-3.2.3 When the pump is of the enclosed line shaft oil-lubricated type, the shaft enclosing tube shall be furnished in interchangeable sections not over 10 ft (3 m) in length of extra strong pipe. An automatic sight feed oiler shall be provided, on a suitable mounting bracket, with connection to the shaft tube for oil-lubricated pumps. (*See Figure A-4-1.1.*)

4-3.3 Bowl Assembly.

4-3.3.1 The pump bowl shall be of close-grained cast iron, bronze, or other suitable material in accordance with the chemical analysis of the water and experience in the area.

4-3.3.2 Impellers shall be of the enclosed or semi-open type and shall be of bronze or other suitable material in accordance with the chemical analysis of the water and experience in the area.

4-3.4 Suction Strainer.

4-3.4.1 A cast or heavy fabricated, corrosion-resistant metal cone or basket-type strainer shall be attached to the suction manifold of the pump. The suction strainer shall have a free area of at least four times the area of the suction connections and the openings shall be sized to restrict the passage of a ½-in. (12.7-mm) sphere.

4-3.4.2 For installations in a wet pit this suction strainer shall be required in addition to the intake screen which is illustrated in Figure A-4-2.2.2.

4-3.5 Fittings.

4-3.5.1 The following fittings shall be required for attachment to the pump:

Automatic air release valve as specifed in 4-3.5.2.

Water level detector as specified in 4-3.5.3.

Discharge pressure gage as specified in 2-5.1.

Relief valve and discharge cone when required by 2-13.1.

Hose valve head and hose valves as specified in 2-14.3 or metering devices as specified in 2-14.2.

4-3.5.2 A 1½-in. pipe size or larger automatic air release valve shall be provided to vent air from the column and the discharge head upon the starting of the pump. This valve will also admit air to the column to dissipate the vacuum upon stopping of the pump. It shall be located at the highest point in the discharge line between the fire pump and the discharge check valve.

4-3.5.3* Each well installation shall be equipped with a suitable water level detector. If an air line is used it shall be corrosion-resistant metal, such as copper. Air lines shall be strapped to column pipe at 10 ft (3 m) intervals.

4-4* Installation.

4-4.1 Pump House. The pump house shall be of such design as will offer the least obstruction to the convenient handling and hoisting of vertical pump parts. The requirements of Sections 2-8 and 8-3 shall also apply.

4-4.2 Outdoor Setting. If in special cases the authority having jurisdiction does not require a pump room and the unit is installed outdoors, the driver shall be screened or enclosed and adequately protected against tampering. The screen or enclosure shall be easily removable and have provision for ample ventilation.

4-4.3 Foundation.

4-4.3.1 Certified dimension prints shall be obtained from the manufacturer.

4-4.3.2 The foundation for vertical pumps shall be substantially built to carry the entire weight of the pump and driver plus the weight of the water contained in it. Foundation bolts shall be provided to firmly anchor the pump to the foundation.

4-4.3.3 The foundation shall be of sufficient area and strength that the load per square inch on concrete does not exceed design standards.

4-4.3.4 The top of the foundation shall be carefully leveled to permit the pump to hang freely in the well or wet pit.

4-4.3.5 Where the pump is mounted over a sump or pit, I beams may be used. When using a right angle gear the driver shall be installed parallel to the beams.

4-5 Driver.

4-5.1 Method of Drive.

4-5.1.1 The driver provided shall be so constructed that the total thrust of the pump (which includes the weight of the shaft, impellers, and hydraulic thrust) can be carried on a

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

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

4-5.1.2 Motors shall be of the vertical hollow shaft type, dripproof, normal starting torque, low starting current, squirrel cage induction type. The motor shall be equipped with a nonreverse ratchet.

4-5.1.3 Gear Drives.

4-5.1.3.1 Gear drives and flexible connecting shafts shall be acceptable to the authority having jurisdiction. They shall be of the vertical hollow shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment. The gear drive shall be equipped with a nonreverse ratchet.

4-5.1.3.2 All gear drives shall be listed and rated by the manufacturer at a load equal to the maximum horsepower and thrust of the pump for which the gear drive is intended.

4-5.1.4 Where horizontal diesel engines are used, it shall be the responsibility of the pump manufacturer to furnish a universal joint coupling of suitable design that will prevent undue strain on either the engine or the pump.

4-5.2 Controls. The controllers for the motor, diesel engine or steam turbine shall comply with specifications for either electric drive controllers in Chapter 7 or engine drive controllers in Chapter 9 of this standard.

4-6 Tests.

4-6.1 Field Acceptance and Subsequent Tests.

4-6.1.1 When the installation is completed, an operating test shall be made in the presence of the customer, the pump manufacturer or its designated representative, and the authority having jurisdiction. Requirements in Section 11-2, "Field Acceptance Tests," shall be followed insofar as they apply, and for well installations the test shall also include a continuous run, long enough to satisfy the authority having jurisdiction that the pump performs as required. In no event shall the test be for less than 1 hour.

4-6.1.2 At annual test time both static and pumping water level shall be determined.

4-7 Operation and Maintenance.

4-7.1 Operation.

4-7.1.1* Before starting the unit for the first time after installation, all electrical connections to the motor, and also the discharge piping from the pump shall be checked. With the top drive coupling removed, the motor shall be momentarily operated to ensure that it rotates in the proper direction. Then the impellers shall be set for proper clearance and the top drive coupling reinstalled.

4-7.1.2* With the above precautions taken the pump shall be started and allowed to run. The operation shall be observed for vibration while running and also for any malfunctioning of the driver.

4-7.2 Maintenance.

4-7.2.1 Manufacturer's instructions shall be carefully followed in making repairs, dismantling, and reassembling pumps.

4-7.2.2 When ordering spare or replacement parts, the pump serial number stamped on the nameplate fastened to the pump head shall be included in the order to make sure the proper parts are provided.

4-7.2.3 Ample head room and access for removal of pump shall be maintained.

Chapter 5 Fire Pumps for High-Rise Buildings

5-1 General.

5-1.1 Application. Fire pumps may be necessary for fire control and extinguishing systems in a high-rise building. Need shall be determined by an evaluation of the water supply requirements and systems design conditions for the particular structure.

5-1.2 Use. Fire pumps may be used for automatic sprinkler systems, standpipe and hose systems, and combined systems (automatic sprinkler systems having standpipe-type hose outlets for fire department use). For requirements of each of the systems, refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*, Chapter 2; and to NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, Chapters 5 and 6.

5-1.3 Scope. This chapter requires compliance with all other chapters of this standard except as otherwise specified herein.

5-2 Pump.

5-2.1 Pumps. Pumps shall be specifically listed for fire service. They shall be used in accordance with their design limitations, to serve specially zoned fire protection systems in high-rise buildings. Where the design conditions of the fire protection system exceed the design limitations of a listed fire pump, the pump shall be specially designed to meet the special requirements of its duty, in accordance with the approval of the authority having jurisdiction.

5-2.2 Unit Assembly Required. The pumping equipment shall be furnished in accordance with the provisions of Section 1-5 of this standard.

5-2.3 Pump Construction Feature. Where a nonlisted pump must be used for high pressure service, its pressure containing parts shall be so designed as to be capable of withstanding, without rupture, the hydrostatic test requirements of 2-16.2.

5-3 Installation. The pump installation shall conform to the applicable provisions of Sections 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, 2-14, 3-4, and 3-5.

5-4 Driver.

5-4.1 General. Diesel engines or electric motors are acceptable for driving fire pumps in high-rise buildings.

5-4.2 Power Supply.

5-4.2.1 Power for driving fire pumps in high-rise buildings shall be selected on the basis of adequacy, reliability, and safety.

5-4.2.2 Where electric motors are used and the height of the structure is beyond the pumping capability of the fire department apparatus, a reliable emergency source of power shall be provided for the fire pump installation.

5-4.2.3 The emergency source of power may be provided either by standby engine-driven fire pumps or by part of other established requirements for emergency power sources for services essential to the safety and welfare of high-rise building occupants.

5-5 Controllers for Drivers.

5-5.1 General. Pumps shall be arranged to operate either automatically or manually, depending on the type of fire protection systems served, the character of the water supplies, and the vertical zoning established for the fire protection systems in the high-rise building. (*See 5-1.2.*)

5-5.2 Listed Controllers. Listed fire pump controllers shall be used in accordance with their design limitations and they shall comply with the applicable sections of this standard that prescribe these controls.

5-6 Tests.

5-6.1 Shop Test. Each pump shall be shop tested in accordance with Section 2-16.

5-6.2 Field Acceptance Tests.

5-6.2.1 Upon completion of the entire fire pump installation, an operating test shall be made in the presence of the purchaser, local fire officials, controller representative, the pump manufacturer or its designated representative, and representative of the authority having jurisdiction. All applicable provisions of Section 11-2 shall be followed.

5-6.2.2 It shall be the responsibility of the installing contractor to make the necessary arrangements for the services of manufacturers' representatives when needed for installation and adjustments of the equipment. In addition, the supplier of the fire pumps and controls shall instruct the owner's operating and maintenance personnel about the systems.

Chapter 6 Electric Drive for Pumps

6-1 General. This chapter outlines the minimum requirements for the source(s) and transmission of electric power to motors driving fire pumps and the minimum performance requirements of all intermediate equipment between the source(s) and the pump, including the motor(s), excepting the fire pump controller and its accessories (*see Chapter 7*). All electrical equipment shall, as a minimum, comply with the provisions of NFPA 70, *National Electrical Code.*

6-2 Power Source(s). Power shall be supplied to the fire pump by one or more of the following sources:

6-2.1 Utility Service. Where power is supplied by a public utility service connection, the service shall be located and arranged to minimize the probability of damage by fire from within the premises and exposing hazards.

6-2.2* Single Power Station. Where power is supplied from a single private power station, the station shall be of noncombustible construction, located and protected to minimize the probability of damage by fire.

6-2.3 Other Sources.

6-2.3.1 Where reliable power cannot be obtained from a private power station or utility service, it shall be from two or more of either of the above or in combination, or one or more of the above in combination with an emergency generator (*see 6-2.3.2*), all as approved by the authority having jurisdiction. The power sources shall be arranged so that a fire at one source will not cause an interruption at the other source(s).

6-2.3.2 Emergency Generator. Where power is supplied by an emergency generator, the generator shall be located and protected in accordance with 6-2.1 and Section 6-7.

6-3 Power Supply Lines.

6-3.1 Circuit Conductors.

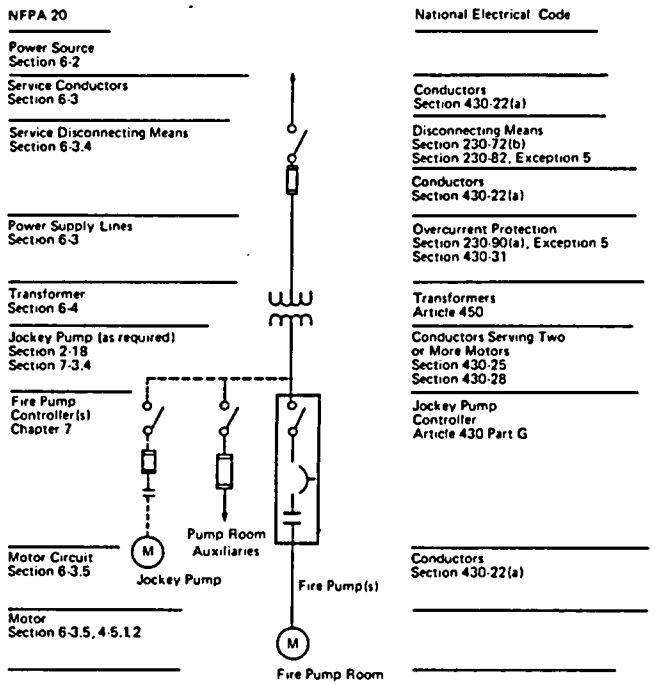
6-3.1.1* The fire pump feeder circuit conductors shall be physically routed outside of the building(s), excluding the electrical switch gear room and the pump room. When the fire pump feeder conductors must be routed through building(s), they shall be buried or enclosed by 2 in. (51 mm) of concrete (or equivalent 1-hour fire resistance) in order to be judged "outside of the building."

6-3.1.2 All pump room wiring shall be in rigid, intermediate, or liquidtight flexible metal conduit.

6-3.1.3 The voltage at the motor shall not drop more than 5 percent below the voltage rating of the motor(s) when the pump(s) are being driven at peak power input and rated speed.

6-3.1.4 The voltage at the controller inlet terminals shall not drop more than 15 percent below normal (controller rated voltage) under motor starting conditions.

6-3.2 The power supply from the source to the motor shall be arranged as shown in Figure 6-3.2



Note: This figure is provided to show the general arrangement of the various components in a fire pump power supply. When used, individual components shall be in accordance with the sections indicated. The pump room auxiliaries and jockey pump power supply can be arranged as shown when other power sources are not available.

Figure 6-3.2 Power Supply from Source to Motor.

6-3.3* The fire pump feeder shall be connected ahead of all plant disconnecting means (1-7.1.3). There shall be no disconnecting means within the fire pump feeder circuit.

Exception: The isolating switch and disconnecting means within the fire pump controller (see Chapter 7).

6-3.4 Power Supply Protecting Devices. A means for disconnecting the plant circuits from the plant power supply shall be provided. This disconnecting means shall be accessible in event of a fire in the property protected or in exposing property. It shall not disconnect the power supply to the fire pump feeder circuit.

6-3.4.1 When power supply protective devices (fuses or circuit breakers) are installed in the power supply circuits at private power stations and utility service connections ahead of the fire pump feeder circuits, such devices shall not open at the sum of the locked rotor currents of the fire pump motor(s) and the maximum plant load.

6-3.4.2 When power supply protective devices (fuses or circuit breakers) are installed in the fire pump feeder circuit, such devices shall not open at the sum of the locked rotor currents of the fire pump motor(s), jockey pump, and associated fire pump accessory equipment.

Exception: Emergency power source feeder protection shall be per 6-7.6.

6-3.5 Capacity of Lines. Each line between the power source and the fire pump motor shall be sized at 125 percent of the sum of the full load currents of the fire pump(s), jockey pump, and fire pump auxiliary loads.

6-4 Transformers.

6-4.1 Installation. Transformers shall be installed in accordance with the requirements of NFPA 70, *National Electrical Code*.

6-5 Motors.

6-5.1 General.

6-5.1.1 All motors shall be specifically listed for fire pump service.

Table 6-5.1.1 Horsepower, Locked Rotor Current Motor Designation

Rated Horsepower	Locked Rotor Current Three-Phase 460 Volts (Amps)	Motor Designation (NEC® Locked-Rotor Indicating Code Letter) "A" to and including
5	46	J
7½	64	H
10	81	H
15	116	G
20	145	G
25	183	G
30	217	G
40	290	G
50	362	G
60	435	G
75	543	G
100	725	G
125	908	G
150	1085	G
200	1450	G
250	1825	G
300	2200	G
350	2550	G
400	2900	G
450	3250	G
500	3625	G

The locked rotor currents for 460-volt motors are approximately six times the full load current. The corresponding values of locked rotor current for motors rated at other voltages shall be determined by multiplication of the values shown by the ratio of 460 volts to the rated voltage.

Code letters of motors for all other voltages shall conform with those shown for 460 volts.

6-5.1.2 All motors shall comply with NEMA standard MG-1 and be marked as complying with NEMA Design B standards.

6-5.1.3 All motors shall be rated for continuous duty and shall not be used at voltages deviating plus or minus 10 percent of the rated voltage.

6-5.2 Current Limits.

6-5.2.1 All motors shall be of such capacity that at rated voltage (and on ac motors at rated frequency) their full load ampere rating will not be exceeded under any conditions of pump load.

Exception: General purpose (open and drip proof) motors shall not have a service factor larger than 1.15. Totally enclosed, fan cooled (TEFC) and totally enclosed nonventilated (TENV) motors shall not have a service factor in excess of 1.0. These service factors shall be in accordance with NEMA Standard MG-1.

6-5.2.2 Motors used at altitudes above 3300 ft (1000 m) shall be operated or derated according to NEMA Standard MG1-Part 14.

6-5.3 Marking.

6-5.3.1 Marking of motor terminals shall be in accordance with NEMA Standard MG1-Part 2.

6-5.3.2 A nameplate shall be provided in accordance with NFPA 70, *National Electrical Code*, Section 430-7.

6-5.3.3 A motor terminal connecting diagram for multiple lead motors shall be furnished.

6-6 Motor Application.

6-6.1 When unusual moisture or abrasive dust conditions are anticipated, motors shall be a special type or especially insulated to withstand such conditions.

6-6.2 Where subject to possible splash of water, motors shall be totally enclosed.

6-6.3 Totally enclosed, fan-cooled motors shall be sealed at the joints and have conduit fittings arranged to prevent the entrance of water.

6-6.4 Current-carrying parts of electric motors shall be at least 12 in. (305 mm) above the floor.

6-7 On-Site Power Generator Systems.

6-7.1 Where on site generator systems are used to supply power to fire pump motors to meet the requirements of 6-2.3.1, 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 loads connected to the generator.

6-7.2 Automatic shedding of loads not required for fire protection is permitted prior to starting of the fire pump(s).

6-7.3 Automatic sequencing of the fire pumps is permitted in accordance with 7-5.2.4.

6-7.4 Transfer of power shall take place within the pump room.

6-7.5 Conductors between the transfer switch and the generator source shall comply with 6-3.1 and 6-3.5.

6-7.6 Protective devices in the on-site power source circuits at the generator shall allow instanenous pickup of the full pump room load.

Chapter 7 Electric Drive Controllers and Accessories

7-1 Application. This chapter provides requirements for the installation and minimum performance of electric controllers, both automatic and nonautomatic, and electric switching equipment for electric motors driving fire pumps. Accessory devices, including alarm monitoring and signaling means, are included when necessary to ensure the minimum performance of the aforementioned equipment.

7-1.1 General.

7-1.1.1 All controllers shall be specifically listed for electric motor driven fire pump service.

(a) The controller and transfer switch shall be suitable for the available short circuit current at line terminals of controller and transfer switch assembly and shall be marked "Suitable for use on a circuit capable of delivering not more than _____ amperes r.m.s. symmetrical at _____ volts a.c."

NOTE: The blank spaces shown shall have appropriate numbers filled in for each installation.

(b) A short-circuit study shall be made to establish the available short-circuit current at the controller in accordance with IEEE 141, *Electric Power Distribution for Industrial Plants*, or IEEE 241, *Electric Systems for Commercial Buildings*.

7-1.1.2 All controllers shall be suitable for use as service equipment and completely assembled, wired, and tested by the manufacturer before shipment from the factory.

7-1.1.3 All controllers shall be marked "Electric Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete electrical rating. Where multiple pumps are provided, one or more serving different areas or portions of the facility, an appropriate sign shall be conspicuously attached to each controller indicating the area, zone, or portion of the system served by that pump or pump controller.

7-1.1.4 It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a manufacturer's representative when needed for service and adjustment of the equipment during the installation, testing, and warranty periods.

7-2 Location.

7-2.1* Controllers shall be located as close as is practical to the motors they control and shall be within sight of the motors.

7-2.2 Controllers shall be so located or so protected that they will not be injured by water escaping from pumps or pump connections. Current-carrying parts of controllers shall be not less than 12 in. (305 mm) above the floor level.

7-2.3 For controllers which require rear access for servicing, a clearance of not less than 3½ ft (1.1 m) shall be provided at the rear of the controller and not less than 2 ft (0.61 m) on at least one side of the controller.

7-3 Construction.

7-3.1 Equipment. All equipment shall be suitable for use in locations subject to a moderate degree of moisture such as a damp basement.

7-3.2 Mounting. All equipment shall be mounted in a substantial manner on a single noncombustible supporting structure.

7-3.3 Enclosures.

7-3.3.1 The structure or panel shall be securely mounted in an enclosure(s) which will protect the equipment against mechanical injury and water dripping on the enclosure from the downward vertical.

7-3.3.2 Grounding. The enclosure shall be grounded (*see NFPA 70, National Electrical Code, Article 250*). Voltage surge protective devices shall be connected to the cabinet grounding lug by a copper wire of suitable size (*see 7-4.1*).

7-3.4 Connections and Wiring.

7-3.4.1 All busbars and connections shall be readily accessible for maintenance work after installation of the controller. This shall be arranged so that disconnection of the external circuit conductors will not be required.

7-3.4.2 Test Provisions. Provisions shall be made within the controller to permit the use of test instruments for measuring all line voltages and currents without disconnecting any conductors within the controller.

7-3.4.3 Busbars and other wiring elements of the controller shall be designed on a continuous duty basis.

Exception: Conductors which are in a circuit only during the motor starting period may be designed accordingly.

7-3.4.4 A fire pump controller shall not be used as a junction box to supply other equipment. Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the fire pump controller.

7-3.5 Protection of Auxiliary Circuits. Circuits that are necessary for proper operation of the controller shall not have overcurrent protective devices connected in them.

7-3.6 External Operation. All switching equipment for manual use in connecting or disconnecting, or starting or stopping the motor shall be externally operable. (*See NFPA 70, National Electrical Code.*) The isolating switch shall meet the requirements of Section 7-4 below.

7-3.7 Wiring Diagrams and Instructions.

7-3.7.1 A wiring diagram shall be provided and permanently attached to the inside of the controller enclosure.

7-3.7.2 All the field wiring terminals shall be plainly marked to correspond with the wiring diagram furnished.

7-3.7.3* Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

7-3.8 Marking. Each motor control device and each switch and circuit breaker shall be marked to plainly indicate the name of the manufacturer, the designated identifying number and the electrical rating in volts, horsepower, amperes, frequency, phases, etc., as may be appropriate. The markings shall be so located as to be visible after installation.

7-4 Components.

7-4.1 Voltage Surge Arrester. Voltage surge arresters complying with ANSI C62.1 or C62.11 shall be installed from each line terminal of the isolating switch to ground (*see 7-3.3.2*). These device(s) shall be rated to suppress voltage surges above rated line voltage.

Exception: These voltage surge arresters shall not be mandatory for controllers rated in excess of 600 volts (see Section 7-6).

7-4.2 Isolating Switch.

7-4.2.1 The isolating switch shall be a manually operable motor circuit switch or a molded case switch, either having a horsepower rating equal to the motor horsepower.

Exception No. 1: A molded case switch having an ampere rating not less than 115 percent of the motor rated full load current (see NFPA 70, National Electrical Code) and also suitable for interrupting the motor locked rotor current, shall be permitted.

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

7-4.2.1 The isolating switch shall be externally operable (*see 7-3.6*).

7-4.2.2 The ampere rating of the isolating switch shall be at least 115 percent of the nameplate current rating of the motor.

7-4.2.3 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.

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

7-4.2.4 The isolating switch operating handle shall be provided with a spring latch which shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit opening or closing of the switch.

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

7-4.3 Circuit Breaker (Disconnecting Means).

7-4.3.1 The motor branch circuit shall be protected by a circuit breaker (*see NFPA 70, National Electrical Code, Article 100*), which shall be connected directly to the load side of the isolating switch and shall have one pole for each ungrounded circuit conductor.

Exception: When the motor branch circuit is transferred to an alternate on-site power generator and is protected by an overcurrent device at the generator (see 6-7.6), the circuit breaker within the fire pump controller may be bypassed when that motor branch circuit is so connected.

7-4.3.2 The circuit breaker shall have the following mechanical characteristics:

1. It shall be externally operable (*see 7-3.6*).
2. It shall trip free of the handle.
3. A nameplate with the legend CIRCUIT BREAKER — DISCONNECTING MEANS in letters not less than 3/8 in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for tripping the circuit breaker.

7-4.3.3* The circuit breaker shall have the following electrical characteristics:

1. Have a continuous current rating not less than 115 percent of the rated full load current of the motor.
2. Have overcurrent sensing elements of the nonthermal type.
3. Provide instantaneous short circuit overcurrent protection.
4.* Have an adequate interrupting rating to provide the suitability rating [*see 7-1.1.1(a)*] of the controller.
5. The circuit breaker shall permit normal starting of the motor without tripping. (*See 6-5.1.2.*)
6. The instantaneous trip setting shall be not more than 20 times the full load current.

Exception: Current limiters, when integral parts of the circuit breaker, may be used to obtain the required interrupting rating providing all of the following requirements are met:

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

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

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

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

NOTE: Current limiters are melting link-type devices which, when used as an integral part of a circuit breaker, limit the current during a short circuit to within the interrupting capacity of the circuit breaker.

7-4.4 Locked Rotor Overcurrent Protection. The only other overcurrent protective device that shall be required and permitted between the isolating switch and the fire pump motor shall be located within the fire pump controller and shall possess the following characteristics:

1. For a squirrel-cage or wound-rotor induction motor, the device shall be:

(a) Of the time delay type having a tripping time between 8 and 20 seconds at locked rotor current (this is approximately 600 percent of rated full load current for a squirrel-cage induction motor).

(b) Calibrated up to and set at 300 percent of motor full load current.

2. For a direct current motor, the device shall be:

(a) Of the instantaneous type.

(b) Calibrated up to and set at 400 percent of motor full load current.

3. There shall be visual means or markings clearly indicated on the device that proper 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 be accomplished by opening the circuit breaker, which shall be of the external manual reset type.

7-4.5 Motor Starter.

7-4.5.1 The motor starter shall be of the magnetic type with a contact in each ungrounded conductor.

7-4.5.2 For electrical operation of reduced voltage starters, timed automatic acceleration of the motor shall be provided. The period of motor acceleration shall not exceed 10 seconds.

7-4.5.3 Starting resistors shall be designed to permit one 5-second starting operation in each 80 seconds for a period of not less than 1 hour.

7-4.5.4 Starting reactors and autotransformers shall be designed to permit one 15-second starting operation in each 240 seconds for a period of not less than 1 hour.

Exception: Designs in accordance with the requirements of NEMA Industrial Control and Systems Standards (Part ICS2-214) for medium duty service are acceptable for controllers over 200 HP.

7-4.5.5 The operating coil for the main contactor shall be supplied directly from the main power voltage and not through a transformer (for controllers of 600 volts or less).

7-4.5.6 No undervoltage, phase loss, frequency sensitive or other sensor(s) shall be installed which prohibit actuation of motor starter automatically or manually.

7-4.6* Alarm and Signal Devices on Controller.

7-4.6.1 Power Available Visible Indicator. A visible indicator shall be connected to a pair of power supply conductors directly on the line side of the motor starter (load side of the circuit breaker). This visible indicator shall demonstrate that operating voltage is available to the contactor coil. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

7-4.6.2 Phase Reversal. Phase reversal on the line side of the motor starter shall be indicated by a visible indicator.

7-4.7 Alarm and Signal Devices Remote from Controller. When the pump room is not constantly attended, audible or visual alarms powered by a source, not exceeding 125 volts, shall be provided at a point of constant attendance. These alarms shall indicate the following:

(a) Controller has operated into a motor running condition. This alarm circuit shall be energized by a separate reliable supervised power source, or from the pump motor power, reduced to not more than 125 volts.

(b)* Loss of line power on line side of motor starter, in any phase. This alarm circuit shall be energized by a separate reliable supervised power source. The phase voltage providing starting coil excitation shall be monitored to indicate loss of availability of such excitation.

(c) Phase reversal on line side of motor starter. This alarm circuit shall be energized by a separate reliable supervised power source, or from the pump motor power, reduced to not more than 125 volts.

7-4.8 Controller Alarm Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions covered in 7-4.7.

7-5 Starting and Control.

7-5.1* Automatic and Nonautomatic.

7-5.1.1 An automatic controller shall be operable also as a nonautomatic controller.

7-5.1.2 A nonautomatic controller shall be actuated by manually initiated electrical means and by manually initiated mechanical means.

7-5.2 Automatic Controller.

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

(a) Each controller for multiple pump installations (including jockey pumps) shall have its own individual pressure sensing line.

(b) The pressure sensing line connection shall be made between the pump discharge check valve and the discharge control valve. Corrosion-resistant metallic pipe or tube and fittings shall be used for the pressure sensing line. This line shall be ½ in. nominal size, be suitable for the system pressure, and be made of material such as brass, copper or series 300 stainless steel.

7-5.2.2 Fire Protection Equipment Control. When the pump supplies special water control equipment (deluge valves, dry-pipe valves, etc.), it may be desirable to start the motor before the pressure-actuated switch(es) would do so. Under such conditions the controller shall be equipped to start the motor upon operation of the fire protection equipment. This equipment shall be a relay of the drop-out type. The relay shall be actuated from a normally closed contact on the fire protection equipment.

7-5.2.3 Manual Electric Control at Remote Station. When additional control stations for causing nonautomatic continuous operation of the pumping unit, independent of the pressure-actuated switch, are provided at locations remote from the controller, such stations shall not be operable to stop the motor.

7-5.2.4 Sequence Starting of Pumps Operating in Parallel. The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one motor from starting simultaneously with any other motor. If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds. Failure of a leading motor to start shall not prevent subsequent pumping units from starting.

7-5.2.5 External Circuits Connected to Controllers. With pumping units operating singly or in parallel, the control circuits leaving or entering the fire pump controller shall be arranged to prevent failure to start due to fault. Breakage, disconnecting, shorting of the wires or loss of power to these circuits may cause continuous running of the fire pump but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits.

7-5.2.6 Sole Supply Pumps. For sprinkler or standpipe systems where an automatically controlled pumping unit constitutes the sole supply, the controller shall be wired for manual shutdown. Manual shutdown shall also be provided where required by the authority having jurisdiction.

7-5.3 Nonautomatic Controller.

7-5.3.1 Manual Electric Control at Controller. There shall be a manually operated switch on the control panel so arranged that, when the motor is started manually, its operation cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down.

7-5.3.2 Emergency Run Mechanical Control at Controller.

(a) The controller shall be equipped with an emergency run handle or lever which operates to close the motor-circuit

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

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

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

7-5.4 Methods of Stopping. Shutdown shall be accomplished by the following methods:

1. Manual — operation of reset pushbutton on outside of controller enclosure which, in the case of automatic controllers, shall return the controller to full automatic position.

2. Automatic shutdown after automatic start (optional) — if controller is set up for automatic shutdown after starting causes have returned to normal, a running period timer set for at least 10 minutes running time shall be used.

7-6 Controllers Rated in Excess of 600 Volts.

7-6.1* Control Equipment. Where equipment rated in excess of 600 volts is accepted, the control equipment shall comply with the requirements of Section 7-1 through 7-5.4.

Exception: 7-6.2 through 7-6.8 below detail respects in which controllers of voltages in excess of 600 do not comply with the referenced sections.

7-6.2 Provisions for Testing. The provisions of 7-3.4.2 shall not apply. An ammeter shall be provided on the controller with a suitable transfer switch arranged for reading the current in each phase. An indicating voltmeter shall also be provided on the controller with scale calibrated to the high voltage supply and deriving its source of power from the control transformer secondary.

7-6.3 Disconnecting Under Load. Provision shall be made to prevent opening the isolating switch under load.

7-6.4 Pressure-Actuated Switch Location. Special precautions shall be taken in locating the pressure-actuated switch called for in 7-5.2.1, to prevent any water leakage from coming in contact with high-voltage components.

7-6.5 Low-Voltage Control Circuit. The low-voltage control circuit shall be supplied from the high-voltage source through a step-down control circuit transformer protected by suitable high-voltage fuses. Its current supply shall be interrupted when the isolating switch is in the open position.

7-6.6 Alarm and Signal Devices on Controller. For these controllers, specifications differ from 7-4.6. A pilot lamp shall be provided to indicate that power is available. The lamp operating voltage shall be less than the lamp voltage rating in order to ensure long life. The current supply for the lamp shall come from the secondary of the control circuit transformer through resistors, if found necessary, or from a small capacity step-down transformer which shall reduce the control transformer secondary voltage to that required for the pilot lamp.

7-6.7 Protection of Personnel from High Voltage. Necessary provisions shall be made, including such interlocks as may be needed, to protect personnel from accidental contact with high voltage.

7-6.8 When the contactor also performs the functions of a circuit breaker, it shall comply with the requirements of 7-4.3, 7-4.4 and 7-5.3.2.

Exception No. 1: In addition to the overcurrent devices providing protection according to 7-4.3 and 7-4.4, current-limiting fuses shall be mounted in the controller enclosure, connected between the isolating means and the contactor, and shall not open under locked rotor current of the motor and shall open the circuit safely under the short-circuit current available at the fuses.

Exception No. 2: When the contactor is latched-in according to 7-5.3.2, the overcurrent protection for a locked rotor condition as specified in 7-4.4(1) is not required.

Exception No. 3: The fuses referred to in 7-4.3.3(4) shall be high voltage current limiting motor starting types.

7-7* Limited Service Controllers. Limited service controllers, complying with the provisions of this sections, consisting of automatic controllers for accross-the-line starting of squirrel-cage motors of 30 hp or less, 600 volts or less, may be installed where such use is acceptable to the authority having jurisdiction. The provisions of Sections 7-1 through 7-5 shall apply.

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

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

NOTE: See 7-4.2.1.

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

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

7-8 Power Transfer for Alternate Power Supply.

7-8.1 General.

7-8.1.1 Where required by the authority having jurisdiction or to meet the requirement of 6-2.3.1 where an on-site electrical switching device is used for power source selection, such switch shall comply with the provisions of this section, as well as Sections 7-1, 7-2, and 7-3.

7-8.1.2 Manual transfer switches shall not be used with automatic fire pump controllers.

7-8.1.3 No remote device(s) shall be installed with the capability of preventing proper operation.

7-8.2* Automatic Transfer Switch Requirements. (*See Figure A-7-8.2.*)

7-8.2.1* When the power transfer switch consists of a self-contained power switching assembly, such assembly shall be housed in a barriered compartment of the fire pump controller or in a separate enclosure adjacent to the controller and marked "Fire Pump Automatic Transfer Switch."

7-8.2.2 The transfer switch shall be specifically listed for fire pump service.

7-8.2.3 One transfer switch shall be dedicated to each fire pump.

7-8.2.4 The transfer switch shall be suitable for the available short circuit currents at the transfer switch normal and alternate input terminals.

7-8.2.5 A means for safe manual (nonelectrical) operation of the automatic transfer switch shall be provided. This manual means need not be externally operable.

7-8.2.6 An isolating switch, complying with 7-4.2, located within the automatic transfer switch enclosure or compartment, shall be provided ahead of the alternate input terminals of the transfer switch.

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

(b) Supervision shall operate an audible and visual signal in the pump room and at a remote point when required.

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

7-8.2.7 The automatic transfer switch shall be provided with undervoltage sensing devices to monitor all ungrounded lines of the normal power source. When the voltage on any phase at the load terminals of the circuit breaker within the fire pump controller falls below 90 percent of motor rated voltage, the transfer swtich shall automatically initiate transfer to the alternate source. When the voltage on all phases of the normal source returns to within acceptable limits, the fire pump controller may be retransferred to the normal source. Phase reversal of the normal source power [*see 7-4.7(c)*] shall cause a simulated normal source power failure upon sensing phase reversal.

Exception: When the automatic transfer switch is electrically upstream of the fire pump controller circuit breaker, voltage may be sensed at the input to the transfer switch in lieu of at the load terminals of the fire pump controller circuit breaker.

7-8.2.8 Voltage- and frequency-sensing devices shall be provided to monitor at least one ungrounded line of the alternate power source. Transfer to the alternate source shall be inhibited until there is adequate voltage and frequency to serve the fire pump load.

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

7-8.2.9 Two visible indicators shall be provided to externally indicate the power source to which the fire pump controller is connected.

7-8.2.10 Means shall be provided to delay retransfer from the alternate source of power to the normal source until the normal source is stabilized. This time delay shall be automatically bypassed if the alternate source fails.

7-8.2.11 Means shall be provided to prevent higher than normal inrush currents when transferring the fire pump motor from one source to the other.

7-8.2.12 Where the alternate source is provided by on-site-power generation, the transfer switch shall not have integral short-circuit or overcurrent protection.

7-8.2.13 Where the alternate source is provided by a second utility power source, the transfer switch emergency side shall be provided with an isolating switch complying with 7-8.2.6 and 7-4.2 and a circuit breaker complying with 7-4.3 and 7-4.4.

7-8.2.14 Where the alternate source is provided by on-site power generation, the following shall be provided:

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

(b) A circuit loop to the alternate source generator whereby either the opening or closing of the circuit will start the alternate source generator (when commanded by the transfer switch). (*See 7-8.2.7.*)

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

7-8.2.15 The fire pump controller and transfer switch (*see 7-8.2.2*) shall each have a cautionary marking to indicate that the isolation switch for both the controller and transfer switch is opened before servicing the controller, transfer switch, or motor.

7-8.2.16 A momentary test switch, externally operable, shall be provided on the enclosure which will simulate a normal power source failure.

Chapter 8 Diesel Engine Drive

8-1 General.

8-1.1 Selection. Selection of diesel engine driven fire pump equipment for each situation shall be based on careful consideration of the following factors: most reliable type of control, fuel supply, installation, and the starting and running operation of the diesel engine.

8-1.2 Experience Record. The compression ignition diesel engine has proved to be the most dependable of the internal combustion engines for driving fire pumps. Except for installations made prior to adoption of the 1974 edition of this standard, spark-ignited internal combustion engines shall not be used. This restriction shall not be interpreted to exclude gas turbine engines as future pump drivers.

8-2 Engines.

8-2.1 Listing.

8-2.1.1 Engines shall be specifically listed for fire pump service by a testing laboratory.

8-2.1.2 Listed engines shall be:

(a) Closed circuit, liquid-cooled with raw water heat enchanger (heat-exchanger-cooled).

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

8-2.2 Engine Ratings.

8-2.2.1 Engines shall be rated at standard SAE conditions of 29.61 in. (7521 mm) Hg barometer and 77°F (25°C) inlet air temperature [approximates 300 ft (91.4 m) above sea level] by the testing laboratory (*see SAE Standard J 1349*).

8-2.2.2 Engines shall be acceptable for horsepower ratings listed by the testing laboratory for standard SAE conditions.

8-2.2.3 In special cases, engines outside the power range and type of listed engines shall have a horsepower capability, when equipped for fire pump driver service, not less than 10 percent greater than the maximum brake horsepower required by the pump under any conditions of pump load. The engine shall meet all the other requirements of listed engines.

8-2.2.4* A deduction of 3 percent from engine horsepower rating at standard SAE conditions shall be made for diesel engines for each 1000 ft (305 m) altitude above 300 ft (91.4 m).

8-2.2.5* A deduction of 1 percent from engine horsepower rating as corrected to standard SAE conditions shall be made for diesel engines for every 10°F (5.6°C) above 77°F (25°C) ambient temperature.

8-2.2.6 Where right angle gear drives (*see 8-2.3.1*) are used between the vertical turbine pump and its driver, the horsepower requirement of the pump shall be increased to allow for power loss in the gear drive. Where integral gear drives are part of a listed engine package and the power is measured at the output shaft of the gearbox, an additional allowance for gear losses is not required.

8-2.2.7 Engines after complying with the requirements of 8-2.2.1 through 8-2.2.6 shall have a 4-hour minimum horsepower rating equal to or greater than the brake horsepower required to drive the pump at its rated speed under any conditions of pump load.

8-2.3 Engine Connection to Pump.

8-2.3.1 Engines shall be connected to horizontal shaft pumps by means of a flexible coupling of a design that has been successfully proven in such service. They shall be connected to vertical shaft pumps by means of a right angle gear drive with suitable universal joints. The service factor used shall be conservatively selected for the maximum horsepower rating of the pumping unit being equal to or greater than the coupling manufacturer's recommended factor for the intended service. The angle of deflection for the flexible connecting shaft shall not exceed the maximum recommended by the manufacturer for the speed and horsepower transmitted.

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

8-2.4 Instrumentation and Control.

8-2.4.1 Governor. Engines shall be provided with a governor capable of regulating engine speed within a range of 10 percent between shutoff and maximum load condition of the pump. The governor shall be field adjustable, set and secured to maintain rated pump speed at maximum pump load. If a manual control throttle is provided, it shall not permit reduction of engine speed below the governor's set and secured point.

8-2.4.2 Overspeed Shutdown Device. Engines shall be provided with an overspeed shutdown device. It shall be arranged to shut down the engine at a speed approximately 20 percent above rated engine speed, and for manual reset. The position of the overspeed shutdown device shall be so supervised that the automatic engine controller will continue to show an overspeed trouble signal until the device is manually reset to normal operating position.

8-2.4.3 Tachometer. A tachometer shall be provided to indicate revolutions per minute of the engine. The tachometer shall be the totalizing type or an hour meter shall be provided to record total time of engine operation.

8-2.4.4 Oil Pressure Gage. Engines shall be provided with an oil pressure gage to indicate lubricating oil pressure.

8-2.4.5 Temperature Gage. Engines shall be provided with a temperature gage to indicate cooling water temperature.

8-2.4.6 Instrument Panel. All engine instruments shall be placed on a suitable panel secured to the engine at a suitable point.

8-2.4.7 Automatic Controller Wiring in Factory. All connecting wires for automatic controllers shall be harnessed or flexibly enclosed, mounted on the engine, and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller. This is to ensure ready wiring in the field between the two sets of terminals.

8-2.4.8* Automatic Control Wiring in the Field. Interconnections between the automatic controller and engine junction box shall be made using stranded wire sized on a continuous duty basis.

8-2.4.9* Main Battery Contactors. The main battery contactors supplying current to the starting motor shall be capable of manual mechanical operation to energize the starting motor in the event of control circuit failure.

8-2.4.10 Signal for Engine Running and Crank Termination. Engines shall be provided with a speed-sensitive switch to signal engine running and crank termination. Power for this signal shall be taken from a source other than the engine generator or alternator.

8-2.4.11 Wiring Elements. All wiring on the engine including starting circuitry shall be sized on a continuous duty basis.

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

8-2.5 Starting Methods.

8-2.5.1 Starting Device. Engine shall be equipped with a reliable starting device.

8-2.5.2 Electric Starting. When electric starting is used, the electric-starting device shall take current from a storage battery(ies).

8-2.5.3 Hydraulic Starting. When hydraulic starting is used the accumulators and other accessories shall be cabinetized or so guarded that they are not subject to mechanical injury. The cabinet shall be installed as close to the engine as practical so as to prevent serious pressure drop between engine and cabinet. The diesel engine as installed shall be without starting aid except that a thermostatically controlled electric water jacket heater should be employed. The diesel as installed shall be capable of carrying its full rated load within 20 seconds after cranking is initiated with the intake air, room ambient and all starting equipment at a temperature of 32°F.

8-2.5.4 Hydraulic starting means shall comply with the following conditions:

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

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

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

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

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

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

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

8-2.6 Storage Battery.

8-2.6.1 Number and Capacity of Batteries. Each engine shall be provided with two storage battery units.

Each battery unit shall have capacity, at 40°F (4.5°C), sufficient to maintain cranking speed recommended by the engine manufacturer through a 6-minute cycle (15 seconds cranking and 15 seconds rest, in 12 consecutive cycles).

8-2.6.2 Battery. Lead-acid batteries shall be furnished in a dry charge condition, with electrolyte liquid in a separate container. Electrolyte shall be added at the time the engine is put in service, and the battery given a conditioning charge. Nickel-cadmium batteries shall be furnished according to the manufacturers' requirements.

8-2.6.3* Battery Recharging. Two means for recharging storage batteries shall be provided. One shall be the generator or alternator furnished with the engine. The other shall be an automatically controlled charger taking power from an alternating current power source. Another reliable charging method shall be specified if an alternating current power source is not available or is not reliable.

8-2.6.4 Battery Chargers.

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

(b) The rectifier shall be a semiconductor type.

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

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

(e) The charger shall be marked with the ampere-hour rating of the largest capacity battery that it can recharge in compliance with 8-2.6.4(d).

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

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

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

(i) When not connected through a control panel, the battery charger shall be arranged to indicate loss of current output on the load side of the dc overcurrent protective device. [*See A-9-4.3.3(a).*]

8-2.6.5* Battery Location. Storage batteries shall be rack supported above the floor, secured against displacement, and located where they will not be subject to excessive temperature, vibration, mechanical injury, or flooding with water. They shall be readily accessible for servicing.

8-2.6.6 Current-carrying parts shall not be less than 12 in. (305 mm) above the floor level.

8-2.7 Engine Cooling.

8-2.7.1 Coolant Circulation. The engine cooling system shall be the closed-circuit type, including a circulating pump driven by the engine, a heat exchanger, and a reliable engine jacket temperature regulating device. An opening shall be provided in the circuit for filling the system, checking coolant level, and adding make-up coolant when required. The coolant shall comply with the recommendation of the engine manufacturer.

8-2.7.2* Exchanger Water Supply.

(a) The cooling water supply for the heat exchanger shall be from the discharge of the pump, taken off prior to the pump discharge valve. Threaded rigid piping shall be used for this connection. The pipe connection shall include an indicating manual shutoff valve, an approved flushing-type strainer in addition to the one that may be a part of the pressure regulator, a pressure regulator, an automatic electric solenoid valve listed for fire protection service, and a second indicating manual shutoff valve in the order shown in Figure A-8-2.7.2. A pressure gage shall be installed in the cooling water supply system on the engine side of the last manual valve.

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

(b) *Pressure Regulator.* The pressure regulator shall be of such size and type that it is capable of, and adjusted for, passing approximately 120 percent of the cooling water required when the engine is operating at maximum brake horsepower, and when the regulator is supplied with water at the pressure of the pump when it is pumping at 150 percent of its rated capacity.

8-2.7.3* Bypass. A bypass line with manual valves and a flush-type strainer shall be installed around the manual shutoff valve, strainer, pressure regulator and solenoid valve as shown in Figure A-8-2.7.2.

8-2.7.4 Waste Outlet. An outlet shall be provided for the waste water line from the heat exchanger, and the discharge line shall not be less than one size larger than the inlet line. The outlet line shall be short, shall provide discharge into a visible open waste cone, and shall have no valves in it.

8-2.7.5 Exhaust Manifold. Listed engines shall incorporate provisions on the exhaust manifold to avoid hazard to the operator or to flammable material adjacent to the engine.

8-3* Pump and Engine Protection.

8-3.1 Pump Room Drainage. The floor or surface around the pump and engine shall be pitched for adequate drainage of escaping water or fuel away from critical equipment such as pump, engine, controller, fuel tank, etc.

8-3.2 Ventilation. Means for thorough ventilation shall be provided and shall be adequate for engine air supply and for removal of hazardous vapors.

8-4 Fuel Supply and Arrangement.

8-4.1 Plan Review. Before any fuel system is installed, plans shall be prepared and submitted to the authority having jurisdiction for agreement on suitability of the system for conditions prevailing.

8-4.2 Guards. A guard or protecting pipe shall be provided for all exposed fuel lines.

8-4.3* Fuel Tank Capacity. Fuel supply tank(s) shall have a capacity at least equal to 1 gal per horsepower (5.07 L/kW), plus 5 percent volume for expansion and 5 percent volume for sump. Larger capacity tanks may be required and shall be determined by prevailing conditions such as refill cycle and fuel heating due to recirculation, and be subject to special conditions in each case. The fuel supply tank and fuel shall be reserved exclusively for the fire pump diesel engine.

8-4.4 Multiple Pumps. There shall be a separate fuel line and separate fuel supply tank for each engine.

8-4.5* Fuel Supply Location. Diesel fuel supply tanks shall be located aboveground in accordance with municipal or other ordinances and in accordance with requirements of the authority having jurisdiction, and shall not be buried. The engine fuel supply (suction) connection shall be located on the tank so that 5 percent of the tank volume provides a sump volume not useable by the engine. The fuel supply shall be located on a side of the tank at the level of the 5 percent sump volume. The inlet to the fuel supply line shall be located so that its opening is no lower than the level of the engine fuel transfer pump. The engine manufacturers fuel pump static head pressure limits must not be exceeded when the level of fuel in the tank is at a maximum. The fuel return line shall be installed per the engine manufacturer's recommendation. In zones where freezing (32°F) (0°C) may be

encountered, the fuel tanks shall be located in the pump room. Means other than sight tubes shall be provided for determining the amount of fuel in each storage tank. Each tank shall have suitable fill, drain, and vent connections.

8-4.6* Fuel Piping. Flame resistant flexible hoses listed for this service shall be provided at the engine for connection to fuel system piping. There shall be no shutoff valve in the fuel return line to the tank. (Figure A-8-4.6 shows a suggested fuel system.)

8-4.7* The type and grade of diesel fuel shall be as specified by the engine manufacturer. Residual fuels, domestic heating furnace oils, and drained lubrication oils shall not be used.

8-4.8 Fuel Solenoid Valve. When an electric solenoid valve is used to control the engine fuel supply, it shall be capable of manual mechanical operation or of being manually bypassed in the event of a control circuit failure.

8-5 Engine Exhaust.

8-5.1 Independent Exhaust. Each pump engine shall have an independent exhaust system.

8-5.2 Exhaust Discharge Location. Exhaust from the engine shall be piped to a safe point outside the pump room and arranged to exclude water. Exhaust gases shall not be discharged where they will affect persons or endanger buildings.

8-5.3* Exhaust Piping. A seamless or welded corrugated (not interlocked) flexible connection shall be made between the engine exhaust outlet and exhaust pipe. The exhaust pipe shall not be any smaller than the engine exhaust outlet and shall be as short as possible. The exhaust piping shall be insulated from combustible materials as specified in NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*. The exhaust pipe shall be covered with high temperature insulation or otherwise guarded to protect personnel from injury. The exhaust pipe and muffler, if used, shall be suitable for the use intended and the exhaust back pressure shall not exceed the engine manufacturer's recommendations.

8-6* Operation and Maintenance.

8-6.1 Weekly Run. Engines shall be started no less than once a week and run for no less than 30 minutes to attain normal running temperature. They shall run smoothly at rated speed.

8-6.2 Engine Maintenance. Engines shall be kept clean, dry, and well lubricated. The proper oil level shall be maintained in the crankcase. Oil shall be changed in accordance with manufacturer's recommendations, but not less frequently than annually.

8-6.3 Battery Maintenance.

8-6.3.1 Storage batteries shall be kept charged at all times. They shall be tested frequently to determine the condition of the battery cells, and the amount of charge in the battery.

8-6.3.2 Only distilled water shall be used in battery cells. The plates shall be kept submerged at all times.

8-6.3.3 The automatic feature of a battery charger is not a substitute for proper maintenance of battery and charger. Periodic inspection of both shall be made. This inspection shall determine that the charger is operating correctly, the water level in the battery is correct, and the battery is holding its proper charge.

8-6.4 Fuel Supply Maintenance. The fuel storage tanks shall be kept as full as possible at all times, but never less than 50 percent of tank capacity. They shall always be filled by means that will ensure removal of all water and foreign material.

8-6.5* Temperature Maintenance. Temperature of the pump room, pump house or area where engines are installed shall never be less than the minimum recommended by the engine manufacturer. The engine manufacturer's recommendations for water heaters and oil heaters shall be followed.

8-6.6 Emergency Starting and Stopping. The sequence for emergency manual operation, arranged in a step-by-step manner, shall be posted on the fire pump engine. It shall be the engine manufacturer's responsibility to list any specific instructions pertaining to the operation of this equipment during the above-mentioned sequences.

8-7 Air Starting.

8-7.1 Existing Requirements. In addition to the requirements in Sections 8-1 through 8-2.4.6; 8-2.5.1; 8-2.7 through 8-6.2; 8-6.4; and 8-6.5, the following sections shall apply.

8-7.2 Automatic Controller Connections in Factory. All conductors for automatic controllers shall be harnessed or flexibly enclosed, mounted on the engine and connected in an engine junction box to terminals numbered to correspond with numbered terminals in the controller. This is to ensure ready connection in the field between the two sets of terminals.

8-7.3 Signal for Engine Running and Crank Termination. Engines shall be provided with a speed-sensitive switch to signal running and crank termination. Power for this signal shall be taken from a source other than the engine compressor.

8-7.4* Air Starting Supply. The air supply container shall be sized for 180 seconds of continuous cranking without recharging. There shall be a separate, suitably powered automatic air compressor or means of obtaining air from some other system, independent of the compressor driven by the fire pump engine. Suitable supervisory service shall be maintained to indicate high and low air pressure conditions.

8-7.5 Air Starting Supply. A bypass conductor with a manual valve or switch shall be installed for direct application of air from the air container to the engine starter in the event of control circuit failure.

Chapter 9 Engine Drive Controllers

9-1 Application. This chapter provides requirements for the installation and minimum performance of diesel engine controllers, both automatic and nonautomatic, for diesel-engine-driven fire pumps. Accessory devices, including alarm monitoring and signaling means, are included when necessary to ensure the minimum performance of the aforementioned equipment.

9-1.1 General.

9-1.1.1 All controllers shall be specifically listed for diesel-engine-driven fire pump service.

9-1.1.2 All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

9-1.1.3 All controllers shall be marked "Diesel Engine Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete electrical rating. Where multiple pumps are provided, one or more serving 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.

9-1.1.4 It shall be the responsibility of the pump manufacturer or its designated representative to make necessary arrangements for the services of a controller manufacturer's representative, when needed, for services and adjustment of the equipment during the installation, testing, and warranty periods.

9-2 Location.

9-2.1* Controllers shall be located as close as is practical to the engines they control and shall be within sight of the engines.

9-2.2 Controllers shall be so located or so protected that they will not be injured by water escaping from pumps or pump connections. Current-carrying parts of controllers shall not be less than 12 inches (305 mm) above the floor level.

9-2.3 For controllers which require rear access for servicing, a clearance of not less than 2½ ft (0.76 m) shall be provided at the rear of controller and not less than 2 ft (0.61 m) on at least one side of the controller.

9-3 Construction.

9-3.1* Equipment. All equipment shall be suitable for use in locations subject to a moderate degree of moisture such as a damp basement. Reliability of operation shall not be adversely affected by normal dust accumulations.

9-3.2 Mounting. All equipment not mounted on the engine shall be mounted in a substantial manner on a single noncombustible supporting structure.

9-3.3 Enclosures.

9-3.3.1 The structure or panel shall be securely mounted in an enclosure(s) which will protect the equipment against mechanical injury and water dripping on the enclosure from the downward vertical.

9-3.3.2 Grounding. The enclosure shall be grounded (*see NFPA 70, National Electrical Code, Article 250*). Voltage surge protective devices shall be connected to the cabinet grounding lug by a copper wire of suitable size (*see 9-4.1*).

9-3.4 Locked Cabinet. All switches required to keep the controller in the "automatic" position shall be within locked cabinets having break glass panels.

9-3.5 Connections and Wiring.

9-3.5.1 Field Wiring. All wiring between the controller and the diesel engine shall be stranded and sized to carry the charging or control currents as required by the controller manufacturer. Such wiring shall be protected against mechanical injury. Controller manufacturer's specifications for distance and wire size shall be followed.

9-3.5.2 Wiring Elements. Wiring elements of the controller shall be designed on a continuous-duty basis.

9-3.5.3 A diesel engine fire pump controller shall not be used as a junction box to supply other equipment. Electrical supply conductors for pressure maintenance (jockey or make-up) pump(s) shall not be connected to the diesel engine fire pump controller.

9-3.6 Wiring Diagrams and Instructions.

9-3.6.1 A field connection diagram shall be provided and permanently attached to the inside of the enclosure.

9-3.6.2 The field connection terminals shall be plainly marked to correspond with the field connection diagram furnished.

9-3.6.3 For external engine connections, the field connection terminals shall be commonly numbered between the controller and engine terminals.

9-3.7 Marking. Each operating component of the controller shall be marked to plainly indicate an identifying number referenced to the schematic diagram. The markings shall be located so as to be visible after installation.

9-3.8* Instructions. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

9-4 Components.

9-4.1 Voltage Surge Arresters. Voltage surge arresters complying with ANSI C62.1 shall be installed from each incoming ungrounded ac terminal of the controller to ground (*see 9-3.3.2*). These devices shall be rated to suppress voltage surges above rated line voltage.

9-4.2 Alarm and Signal Devices on Controller.

9-4.2.1 Visible Indicators. All visible indicator alarms shall be plainly visible.

9-4.2.2* Visible indication shall be provided to indicate that the controller is in the "automatic" position. If the visible indicator is a pilot lamp, it shall be accessible for replacement.

9-4.2.3 Separate visible indicators and a common audible alarm capable of being heard while the engine is running, and operable in all positions of the main switch except "off," shall be provided to indicate trouble caused by the following conditions:

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

(b) High engine jacket coolant temperature.

(c) Failure of engine to start automatically.

(d) Shutdown from overspeed.

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

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

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

(g) Low Air or Hydraulic Pressure. When air or hydraulic starting is provided (*see 8-2.5 and 8-7*), each pressure tank shall provide to the controller separate visible indicators to alarm low pressure.

9-4.2.4 No audible alarm silencing switch, other than the controller main switch, shall be permitted for the alarms in 9-4.2.3.

9-4.2.5 When audible alarms for the conditions listed in A-2-17 are incorporated with the engine alarms specified in 9-4.2.3, a silencing switch for the A-2-17 audible alarms shall be provided at the controller. The circuit shall be so arranged that the audible alarm will be activated if the silencing switch is in the "silent" position when the supervised conditions are normal.

9-4.3 Alarm and Signal Devices Remote from Controller. When the pump room is not constantly attended, audible or visible alarms powered by a source other than the engine starting batteries, and not exceeding 125 volts, shall be provided at a point of constant attendance. These alarms shall indicate the following:

9-4.3.1 Engine running (separate signal).

9-4.3.2 That controller main switch has been turned to "off" or "manual" position (separate signal).

9-4.3.3* Trouble on the controller or engine (separate or common signals). See 9-4.2.3.

9-4.4 Controller Alarm Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions covered in 9-4.3.

9-4.5 Pressure Recorder. The controller shall be equipped with a pressure recording device which shall operate continuously for at least 7 days without resetting or rewinding. The pressure recording device shall be spring wound mechanically or driven by reliable electrical means. The pressure recording device shall not be solely dependent upon ac electric power as its primary power source. Upon loss of ac electric power, the electric driven recorder shall be capable of at least 24 hours of operation.

9-5* Starting and Control.

9-5.1 Automatic and Nonautomatic.

9-5.1.1 An automatic controller shall be operable also as a nonautomatic controller.

9-5.1.2 The controller(s) primary source of power shall not be ac electric power.

9-5.2 Automatic Operation of Controller.

9-5.2.1 Water Pressure Control. The controller circuit shall be provided with a pressure-actuated switch having independent high and low calibrated adjustments. There shall be no pressure snubber or restrictive orifice employed within the pressure switch. This switch shall be responsive to water pressure in the fire protection system. The pressure sensing element of the switch shall be capable of a momentary surge pressure of 400 psi (27.6 bars) minimum without losing its accuracy. Suitable provision shall be made for relieving pressure to the pressure-actuated switch, to allow testing of the operation of the controller and the pumping unit. (*See Figure A-7-5.2.1.*)

(a) Each controller for multiple pump installations shall have its own individual pressure sensing line.

(b) The pressure sensing line connection shall be made between the pump discharge check valve and the discharge control valve. Corrosion-resistant metallic pipe or tube and fittings shall be used for the pressure sensing line. This line shall be ½ in. nominal size, be suitable for the system pressure, and be made of material such as brass, copper or series 300 stainless steel.

9-5.2.2 Fire Protection Equipment Control. When the pump supplies special water control equipment (deluge valves, dry-pipe valves, etc.) it may be desirable to start the engine before the pressure-actuated switch(es) would do so. Under such conditions the controller shall be equipped to start the engine upon operation of the fire protection equipment. This equipment shall be a relay of the drop-out type or comparable circuit. This circuit shall be actuated from a normally closed contact on the fire protection equipment, with this circuit supplied by the batteries.

9-5.2.3 Manual Electric Control at Remote Station. Additional control stations for causing nonautomatic, continuous operation of the pumping unit, independent of the pressure-actuated control switch, may be provided at locations remote from the controller. Such stations shall not be

operable to stop the unit except through the established operation of the running period timer circuit when the controller is arranged for automatic shutdown. [*See 9-5.4.2(a).*]

9-5.2.4 Sequence Starting of Pumps Operating in Parallel. The controller for each unit of multiple pump units shall incorporate a sequential timing device to prevent any one engine from starting simultaneously with any other engine. If water requirements call for more than one pumping unit to operate, the units shall start at intervals of 5 to 10 seconds. Failure of a leading engine to start shall not prevent subsequent engines from starting.

9-5.2.5 External Circuits Connected to Controllers. With pumping units operating singly, or in parallel, the control circuits entering or leaving the fire pump controller shall be so arranged as to prevent failure to start due to fault. Breakage, disconnecting, shorting of the wires or loss of power to these circuits may cause continuous running of the fire pump, but shall not prevent the controller(s) from starting the fire pump(s) due to causes other than these external circuits.

9-5.2.6 Sole Supply Pumps. For sprinkler or standpipe systems where an automatically controlled pumping unit constitutes the sole supply, the controller shall be wired for manual shutdown. Manual shutdown shall also be provided where required by the authority having jurisdiction.

9-5.2.7 Weekly Program Timer. To assure dependable operation of the engine and its controller, the controller equipment shall be arranged to automatically start and run the engine for at least 30 minutes once a week. A solenoid valve drain on the pressure control line shall be the initiating means.

Performance of this weekly program timer shall be recorded as a pressure drop indication on the pressure recorder (*see 9-4.5*).

9-5.3 Nonautomatic Operation of Controller.

9-5.3.1 Manual Electric Control at Controller. There shall be a manually operated switch on the controller panel. This switch shall be so arranged that operation of the engine, when manually started, cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down.

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

9-5.3.2 Starting Equipment Arrangement.

(a) Two storage battery units, each complying with the requirements of 8-2.6, "Storage Battery," shall be provided and so arranged that manual and automatic starting of the engine can be accomplished with either battery unit. The starting current shall be furnished by first one battery and then the other on successive operations of the starter. The changeover shall be made automatically, except for manual start.

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

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

9-5.4 Methods of Stopping.

9-5.4.1 Manual Electric Shutdown. Manual shutdown shall be accomplished by either of the following:

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

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

9-5.4.2* Automatic Shutdown After Automatic Start.

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

(b) When the engine emergency overspeed device operates, the controller shall cause the engine to shut down without time delay and lock out until manually reset. Resetting of the overspeed circuit shall be required at the engine and by resetting the controller main switch to the "off" position.

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

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

9-5.5 Emergency Control. Automatic control circuits, the failure of which could prevent engine starting and running, shall be completely bypassed during manual start and run.

9-6 Air Starting Engine Controllers.

9-6.1 Existing Requirements. In addition to the requirements in Sections 9-1 and 9-1.1.1; 9-1.1.4 through 9-3.4; 9-3.8; 9-5 through 9-5.2.1(b); 9-5.2.4; 9-5.2.7; and 9-5.4.2 through 9-5.5, the following sections shall apply.

9-6.2 All controllers shall be completely assembled and tested by the manufacturer before shipment from the factory.

9-6.3 All controllers shall be marked "Diesel Engine Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation, and the complete rating. Where multiple pumps are provided, one or more serving 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.

9-6.4 Connections.

9-6.4.1 Field Connections. All conductors from the panel to the engine and starter support shall have adequate current-carrying capacity. Such conductors shall be protected against mechanical injury. Controller manufacturer's specifications for distance and conductor size shall be followed.

9-6.4.2 Conductor Elements. Conductor elements of the controller shall be designed to operate on a continuous duty basis.

9-6.5 Circuit Diagrams and Instructions.

9-6.5.1 A circuit diagram shall be provided and permanently attached to the inside of the enclosure showing exact circuitry for the controller, including identifying numbers of individual components. All circuit terminals shall be plainly and commonly marked and numbered to correspond with the circuit diagram furnished. For external engine connections, the connection strips shall be commonly numbered.

9-6.6 Marking. Each operating component of the controller shall be marked to plainly indicate an identifying number referenced to the circuit diagram. The markings shall be located so as to be visible after installation.

9-6.7 Alarm and Signal Devices on Controller.

9-6.7.1 A visual indicator(s) shall be provided to indicate that the controller is in the "automatic" position. The visual indicator shall be accessible for replacement.

9-6.7.2 Separate visual indicators and a common audible alarm shall be provided to indicate trouble caused by the following conditions:

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

(b) High engine-jacket-coolant temperature.

(c) Failure of engine to start automatically.

(d) Shutdown from overspeed.

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

9-6.7.3 No audible alarm silencing switch or valve, other than the controller main switch or valve, shall be permitted for the alarms in 9-6.7.2.

9-6.7.4 When audible alarms for the conditions listed in A-2-18 are incorporated with the engine alarms specified in 9-6.7.2 a silencing switch or valve for the A-2-18 audible alarms shall be provided at the controller. The circuit shall be so arranged that the audible alarm will be activated if the silencing switch or valve is in the "silent" position when the supervised conditions are normal.

9-6.8 Alarms for Remote Indication. Controllers shall be equipped to operate circuits for remote indication of the conditions covered in 9-4.2.3, 9-4.3.1, 9-4.3.2, and 9-4.3.3.

9-6.9 Pressure Recorder. The controller shall be equipped with a pressure recording device that shall operate continuously for at least 7 days without resetting or rewinding. The pressure recording device shall be spring wound mechanically, air powered, or driven by reliable electrical means. The pressure recording device shall not be solely dependent upon ac electric power as its primary power source. Upon loss of ac electric power, the electric driven recorder shall be capable of at least 24 hours of operation.

9-6.10 Fire Protection Equipment Control. When the pump supplies special water control equipment (deluge valves, dry-pipe valves, etc.), it may be desirable to start the engine before the pressure-actuated valve or switch would do so. Under such conditions the controller shall be equipped to start the engine upon operation of the fire protection equipment.

9-6.11 Manual Control at Remote Station. Additional control stations for causing nonautomatic, continuous operation of the pumping unit, independant of the pressure-actuated control valve or switch, may be provided at locations remote from the controller. Such stations shall not be operable to stop the unit except through the established operation of the running period timer circuit when the controller is arranged for automatic shutdown. [*See 9-5.4.2(a).*]

9-6.12 External Circuits Connected to Controllers. With pumping units operating singly, or in parallel, the control conductors entering or leaving the fire pump controller shall be so arranged as to prevent failure to start due to fault. Breakage, disconnecting, or loss of power to these conductors may cause continuous running of the fire pump, but shall not prevent the controller(s) from starting the fire pump(s).

9-6.13 Sole Supply Pumps. For sprinkler or standpipe systems where an automatically controlled pumping unit constitutes the sole supply, the controller shall be arranged for manual shutdown. Manual shutdown shall also be provided where required by the authority having jurisdiction.

9-6.14 Nonautomatic Operation of Controller.

9-6.14.1 Manual Control at Controller. There shall be a manually operated valve or switch on the controller panel. This valve or switch shall be so arranged that operation of the engine, when manually started, cannot be affected by the pressure-actuated switch. The arrangement shall also provide that the unit will remain in operation until manually shut down.

9-6.15 Starting Equipment Arrangement.

(a) The air supply container, complying with the requirements of 8-7.4, "Air Starting Supply," shall be provided and so arranged that manual and automatic starting of the engine can be accomplished.

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

9-6.16 Methods of Stopping.

9-6.16.1 Manual Shutdown. Manual shutdown shall be accomplished by either of the following:

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

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

Chapter 10 Steam Turbine Drive

10-1 General.

10-1.1 Acceptability.

10-1.1.1 Steam turbines of adequate power are acceptable prime movers for driving fire pumps. Reliability of the turbines shall have been proved in commercial work.

10-1.1.2 The steam turbine shall be directly connected to the fire pump.

10-1.2 Turbine Capacity.

10-1.2.1 For steam boiler pressures not exceeding 120 psi (8 bars) gage, the turbine shall be capable of driving the pump at its rated speed and maximum pump load with a pressure as low as 80 psi (5.5 bars) gage at the turbine throttle, when exhausting against atmospheric back pressure, with the hand valve open.

10-1.2.2 For steam boiler pressures exceeding 120 psi (8 bars) gage, where steam is continuously maintained, a pressure 70 percent of the usual boiler pressure shall take the place of the 80 psi (5.5 bars) in 10-1.2.1.

10-1.2.3 In ordering turbines for centrifugal fire pumps, the purchaser shall specify the rated and maximum pump loads at rated speed, the rated speed, the boiler pressure, the steam pressure at the turbine throttle (if possible), and the steam superheat.

10-1.3* Steam Consumption. Prime consideration shall be given to the selection of a turbine having a total steam consumption commensurate with the steam supply available. When multistage turbines are used, they shall be so designed that the pump can be brought up to speed without a "warm up" time requirement.

10-2* Turbine.

10-2.1 Casing and Other Parts.

10-2.1.1* The casing shall be designed to permit access with the least possible removal of parts or piping.

10-2.1.2 A safety valve shall be connected directly to the turbine casing to relieve high steam pressure in the casing.

10-2.1.3 The main throttle valve shall be located in a horizontal run of pipe connected directly to the turbine. There shall be a water leg on the supply side of the throttle valve. This leg shall be connected to a suitable steam trap to automatically drain all condensate from the line supplying steam to the turbine. Steam and exhaust chambers shall be equipped with suitable condensate drains. When the turbine is automatically controlled, these drains shall discharge through adequate traps. In addition, if the exhaust pipe discharges vertically, there shall be an open drain at the bottom elbow. This drain shall not be valved but shall discharge to a safe location.

10-2.1.4 The nozzle chamber, governor-valve body, pressure regulator, and other parts through which steam passes shall be made of a metal able to withstand the maximum temperatures involved.

10-2.2 Speed Governor.

10-2.2.1 The steam turbine shall be equipped with a speed governor set to maintain rated speed at maximum pump load. The governor shall be capable of maintaining, at all loads, the rated speed within a total range of approximately 8 percent from no turbine load to full rated turbine load:

(a) With normal steam pressure and with hand valve closed, or

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

10-2.2.2 While the turbine is running at rated pump load, the speed governor shall be capable of adjustment to secure speeds approximately 5 percent above and 5 percent below the rated speed of the pump.

10-2.2.3 There shall also be provided an independent emergency governing device. It shall be arranged to shut off the steam supply at a turbine speed approximately 20 percent higher than the rated pump speed.

10-2.3 Gage and Gage Connections.

10-2.3.1 A listed steam pressure gage shall be provided on the entrance side of the speed governor. A ¼-in. pipe tap for a gage connection shall be provided on the nozzle chamber of the turbine.

10-2.3.2 The gage shall indicate pressures not less than one and one-half times the boiler pressure, and in no case less than 240 psi (16 bars), and shall be marked STEAM.

10-2.4 Rotor. The rotor of the turbine shall be of suitable material. The first unit of a rotor design shall be type tested in the manufacturer's shop at 40 percent above rated speed. All subsequent units of the same design shall be tested at 25 percent above rated speed.

10-2.5 Shaft.

10-2.5.1 The shaft of the turbine shall be of high-grade steel, such as open-hearth carbon steel or nickel steel.

10-2.5.2 Where the pump and turbine are assembled as independent units, a flexible coupling shall be provided between the two units.

10-2.5.3 Where an overhung rotor is used, the shaft for the combined unit shall be in one piece, with only two bearings.

10-2.5.4 The critical speed of the shaft shall be well above the highest speed of the turbine so that the turbine will operate at all speeds up to 120 percent of rated speed without objectionable vibration.

10-2.6 Bearings. Turbines having sleeve bearings shall have split-type bearing shells and caps.

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

10-3* Installation. Details of steam supply, exhaust and boiler feed need to be carefully planned to provide reliability and effective operation of a steam turbine driven fire pump.

Chapter 11 Acceptance, Operation, and Maintenance

11-1 Hydrostatic Tests and Flushing.

11-1.1 Piping shall be hydrostatically tested at not less than 200 psi (13.8 bars) pressure for 2 hours, or at 50 psi (3.4 bars) in excess of the maximum pressure, when the maximum pressure to be maintained in the system is in excess of 150 psi (10.3 bars).

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

11-1.3 The installing contractor shall furnish certificate of test prior to start of fire pump field acceptance test.

Table 11-1.2

Pipe Size	Flow	
(In.)	GPM	L/min
4	390	1476
5	620	2346
6	880	3331
8	1560	5905
10	2440	9235
12	3520	13 323

11-2 Field Acceptance Tests.

11-2.1 The pump manufacturer, the engine manufacturer (when supplied), the controller manufacturer, the transfer switch manufacturer (when supplied) or their representative shall be present for the field acceptance test. (*See Section 1-5.*)

11-2.2* The authority having jurisdiction shall be notified as to time and place of the field acceptance test.

11-2.3 A copy of the manufacturer's certified pump test characteristic curve shall be available for comparison of results of field acceptance test. The fire pump as installed shall equal the performance as indicated on the manufacturer's certified shop test characteristic curve within the accuracy limits of the test equipment.

11-2.4 The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component.

11-2.5 Vibrations of the fire pump assembly shall not be of a magnitude to warrant potential damage to any fire pump component.

11-2.6 Field Acceptance Test Procedures.

11-2.6.1* Test Equipment. Test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor driven pumps, and speed.

11-2.6.2* Flow Tests. The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices.

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

11-2.6.3* Measurement Procedure. The quantity of water discharging from the fire pump assembly shall be determined and stabilized. Immediately thereafter, the operating conditions of the fire pump and driver shall be measured.

11-2.6.3.1 For electric motors operating at rated voltage and frequency, the ampere demand shall not exceed the product of a full load ampere rating times the allowable service factor as stamped on the motor nameplate.

11-2.6.3.2 For electric motors operating under varying voltage, the product of the actual voltage and current demand shall not exceed the product of the rated voltage and rated full load current times the allowable service factor. The voltage at the motor shall not vary more than 5 percent below or 10 percent above rated (nameplate) voltage during the test. (*See 6-3.1.3.*)

11-2.6.3.3 Engine driven units shall not show signs of overload or stress. The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed. (*See 8-2.4.1.*)

11-2.6.3.4 Steam turbine shall maintain its speed within the limits as specified in 10-2.2.

11-2.6.3.5 The gear drive assembly shall operate without excessive objectionable noise, vibration, or heating.

11-2.6.4 Loads Start Test. The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load.

11-2.7 Controller Acceptance Test.

11-2.7.1 Fire pump controllers shall be tested in accordance with the manufacturer's recommended test procedure. As a minimum, no less than 10 automatic and 10 manual operations shall be performed during the acceptance test.

11-2.7.2 A fire pump driver shall be operated for a period of at least 5 minutes at full speed during each of the above operations.

11-2.7.3 The automatic operation sequence of the controller shall start the pump from all provided starting features. This shall include pressure switches or remote starting signals.

11-2.7.4 Tests of engine drive controllers shall be divided between both sets of batteries.

11-2.8 Alternate Power Supply. On installations with an alternate source of power and an automatic transfer switch, loss of primary source shall be simulated and transfer shall occur while the pump is operating at peak load. Transfer from normal to emergency source and retransfer from emergency to normal source shall not cause opening of overcurrent protection devices in either line. At least half of the manual and automatic operations of 11-2.7.1 shall be performed with the fire pump connected to the alternate source.

11-2.8.1 Generator sets serving fire pump installations shall be inspected weekly and shall be exercised for at least 30 minutes once every month. A written record of inspection, performance, operation, and repairs shall be kept and available for inspection by the authority having jurisdiction.

11-2.9 Emergency Governor. Emergency governor valve for steam shall be operated to demonstrate satisfactory performance of the assembly (hand tripping will be accepted).

11-2.10 Alarm conditions, both local and remote, shall be simulated to demonstrate satisfactory operation.

11-2.11 Test Duration. The fire pump shall be in operation for not less than 1 hour total time during all of the foregoing tests.

11-3 Annual Fire Pump Tests.

11-3.1 The annual flow test (*see 11-2.6.2*) shall be conducted to determine its ability to continue to attain satisfactory performance at shutoff, rated and peak loads. All alarms shall operate satisfactorily. All valves in the suction line shall be checked to assure that they are fully open. The pressure relief valve, if installed, shall be verified by actual test to be correctly adjusted and set to relieve at the appropriate pressure.

11-3.2 The annual test shall be performed by personnel trained in the operation of the fire pump. Test results shall be recorded. The speed of the pump driver shall be determined and recorded.

11-3.3* Any significant reduction in the operating characteristics of the fire pump assembly shall be reported to the owner and repairs made immediately.

11-4* Fire Pump Operation.

11-4.1 The fire pump shall be maintained in readiness for operation. After any test, the fire pump shall be returned to automatic operation. All valves shall be returned to normal operating position.

11-4.2 The fire pump room shall be kept clean, dry, orderly, and free of miscellaneous storage. Access to this room shall be restricted.

11-4.3 In the event of fire pump operation, qualified personnel shall be dispatched to the fire pump room to determine that the fire pump is operating in a satisfactory manner.

11-4.4 The fire pump unit shall be operated weekly and at least one start shall be accomplished by reducing the water pressure. This may be done with a test drain on the sensing line or with flow from the fire protection system.

11-4.5 Qualified operating personnel shall be in attendance during the weekly pump operation. The satisfactory performance of the pump driver, controller, and alarms shall be observed and noted.

11-5 Fire Pump Maintenance.

11-5.1* A preventive maintenance program shall be established in accordance with the pump manufacturer's recommendations. Records shall be maintained on all work performed on the pump, driver, and controller.

Chapter 12 Referenced Publications

12-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

12-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13-1989, *Standard for the Installation of Sprinkler Systems.*

NFPA 14-1990, *Standard for the Installation of Standpipe and Hose Systems.*

NFPA 24-1987, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

NFPA 37-1984, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.*

NFPA 70-1990, *National Electrical Code*, Sections 230-2 Exception No. 1, 230-82 Exception No. 5, 230-44.

NFPA 70-1990, *National Electrical Code*, Sections 430-22(a) (excluding exception), 430-23(a), 430-24, 430-25.

NFPA 70-1990, *National Electrical Code*, Sections 450-3, 450-9, 450-10, 450-11.

NFPA 70-1990, *National Electrical Code*, Section 430-7.

NFPA 70-1990, *National Electrical Code*, Section 230-78.

NFPA 1963-1985, *Standard for Screw Threads and Gaskets for Fire Hose Connections.*

12-1.2 Other Codes and Standards.

NEMA Industrial Control-Systems Stds Part ICS2-214 and NEMA MG1-1978 Parts 2 and 14, National Electrical Manufacturers Assn., 155 East 44th Street, New York, NY 12305.

SAE J-1349-1980, *Engine Power Test Code-Spark Ignition and Diesel*, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

Hydraulics Institute Standards for Centrifugal, Rotary and Reciprocating Pumps (1975) (Fourteenth Edition), Hydraulic Institute, 1230 Keith Building, Cleveland, OH 44115.

Appendix A

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

A-1-4 Because of the unique nature of fire pump units, the approval should be obtained prior to the assembly of any specific component.

A-1-5.1 A single entity should be designated as having unit responsibility for the pump, driver, controller, transfer switch equipment and accessories. Unit responsibility means the accountability to answer and resolve any and all problems as regards the proper installation, compatibility, performance, and acceptance of the equipment. Unit responsibility should not be construed to mean purchase of all components from a single supplier.

A-1-7.6 Head. Head is 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. In terms of foot-pounds (m-kg) of energy per pound (kg) of water, all head quantities have the dimensions of feet (m) of water. All pressure readings are converted into feet (m) of the water being pumped (*see Figure A-1-7.6*).

A-1-7.7.8 A can pump is not recommended when listed horizontal split case pumps are available.

A-2-1.1 For water supply capacity and pressure requirements, refer to:

(a) NFPA 13, *Standard for the Installation of Sprinkler Systems*, Chapter 2.

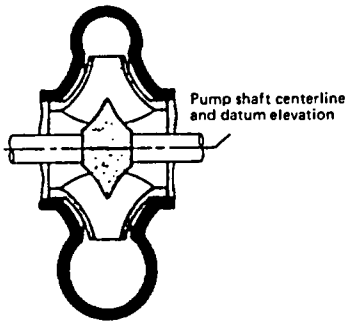
(b) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, Chapter 5.

(c) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, Chapter 3.

(d) NFPA 16, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*, Chapter 3.

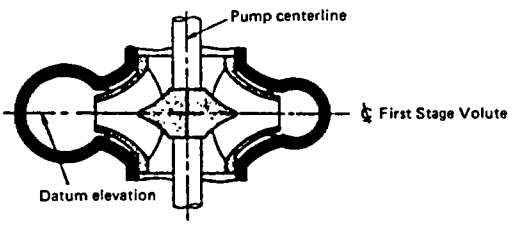
(e) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, Chapter 2.

A-2-1.2 Where the suction supply is from a factory use water system, pump operation at 150 percent of rated capacity should not create hazardous process upsets due to low water pressure.



Horizontal Double Suction Pump

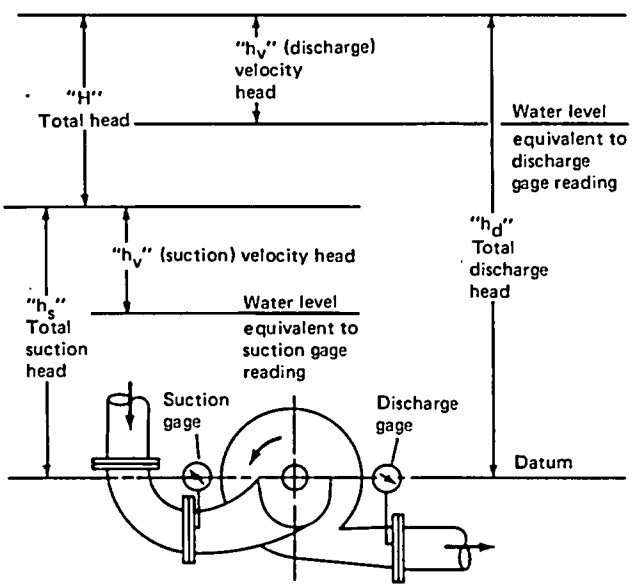
For all types of horizontal shaft pumps (single stage double suction pump shown). Datum is same for multistage, single (end) suction "ANSI" type, or any pump with a horizontal shaft.



Vertical Double Suction Pump

For all types of vertical shaft pumps (single stage vertical double suction pump shown). Datum is same for single (end) suction, "in line," or any pump with a vertical shaft.

Figure A-1-7.6 Datum Elevation of Various Centrifugal Pump Designs.



Installation with suction head above atmospheric pressure shown.

Figure A-1-7.6.7 Total Head of all Types of Centrifugal (Not Vertical Turbine-type) Fire Pumps. Pictorial does not show the various types of pumps applicable.

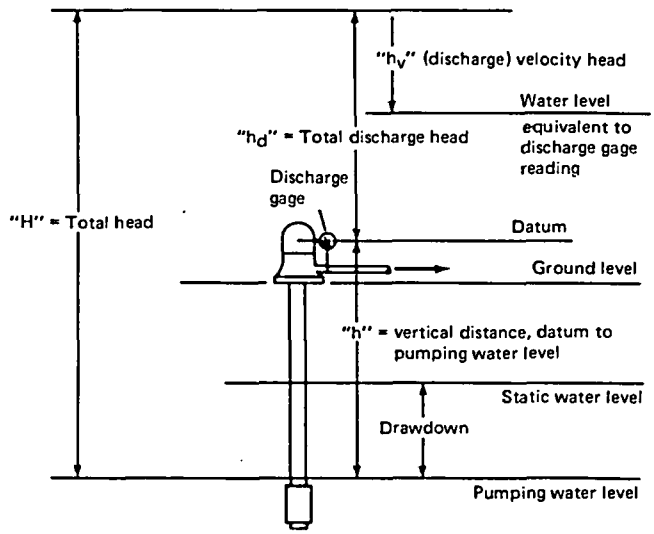


Figure A-1-7.6.8 Total Head of Vertical Turbine-type Fire Pumps.

A-2.1.4 Water sources containing salt or other materials deleterious to the fire protection systems should be avoided.

A-2-3.1 A centrifugal fire pump should be selected in the range of operation from 90 percent to 150 percent of its rated capacity. The performance of the pump when applied at capacities over 140 percent of rated capacity may be adversely affected by the suction conditions. Application of the pump at capacities less than 90 percent of the rated capacity is not recommended.

The selection and application of the fire pump should not be confused with pump operating conditions. With proper suction conditions, the pump can operate at any point on its characteristic curve from shutoff to 150 percent of its rated capacity.

A-2-5.2 For protection against damage from overpressure, when desired, a gage protector should be installed.

A-2-7 Some locations or installations may not require a pump house. When a pump room or pump house is required, it should be of ample size and located to permit short and properly arranged piping. The suction piping should receive first consideration. The pump house should preferably be a detached building of noncombustible construction. A one-story pump room with a combustible roof, either detached or well cut off from an adjoining one-story building, is acceptable if sprinklered. When a detached building is not feasible, the pump room should be so located and constructed as to protect the pump unit and controls from falling floors or machinery, and from fire that might drive away the pump operator or damage the pump unit or controls. Access to the pump room should be provided from outside the building. Where the use of brick or reinforced concrete is not feasible, metal lath and plaster is recommended for the construction of the pump room. The pump room or pump house should not be used for storage purposes. Vertical shaft turbine-type pumps may require a removable panel in the pump house roof to permit the pump to be removed for inspection or repair. Proper clearances to equipment should be provided as recommended by the manufacturer's drawings.

A-2-7.1 Impairment. A fire pump which is inoperative for any reason at any time constitutes an impairment to the fire protection system. It should be returned to service without delay.

Rain and intense heat of the sun are adverse conditions to equipment not installed in a completely protective enclosure. At a minimum, equipment installed outdoors should be shielded by a roof or deck.

A-2-7.6 Pump rooms and pump houses should be dry and free of condensate. Some heat may be required to accomplish this.

A-2-8.1 The exterior of aboveground steel piping should be kept painted.

A-2-9.1 The exterior of steel suction piping should be kept painted.

Buried iron or steel pipe should be lined and coated or protected against corrosion in conformance with applicable AWWA or equivalent standards (AWWA-C104).

A-2-9.4 The suction pipe size should be such that with the pump(s) operating at 150 percent of rated capacity the velocity in the suction pipe does not exceed 15 ft per second (4.57 m/s).

A-2-9.7 Where the suction supply is from public water mains, the gate valve should be located as far as is practical from the suction flange on the pump. Where it comes from a stored water container, the gate valve should be located at the outlet of the container. A butterfly valve can create turbulence adversely affecting the pump performance.

A-2-9.8 When selecting screen material, consideration should be given to prevention of fouling from aquatic growth. This is best accomplished with brass or copper wire.

A-2-9.9 A reduced pressure backflow preventer valve or device should not be installed in the fire pump suction pipe. A backflow preventer valve or device should not be installed in the fire pump suction pipe.

A-2-10.3 The discharge pipe size should be such that with the pump(s) operating at 150 percent of rated capacity the velocity in the discharge pipe does not exceed 20 ft per second (6.2 m/s).

A-2-10.4 Large fire protection systems sometimes experience severe water hammer caused by back flow when the automatic control shuts down the fire pump. Where conditions may be expected to cause objectionable water hammer, a listed anti-water-hammer check valve should be installed in the discharge line of the fire pump. Automatically controlled pumps in high buildings might give trouble from water hammer as the pump is shutting down.

A-2-12 Pipe breakage caused by movement can be greatly lessened, and in many cases prevented, by increasing flexibility between major parts of the piping. One part of the piping should never be held rigidly and another should be free

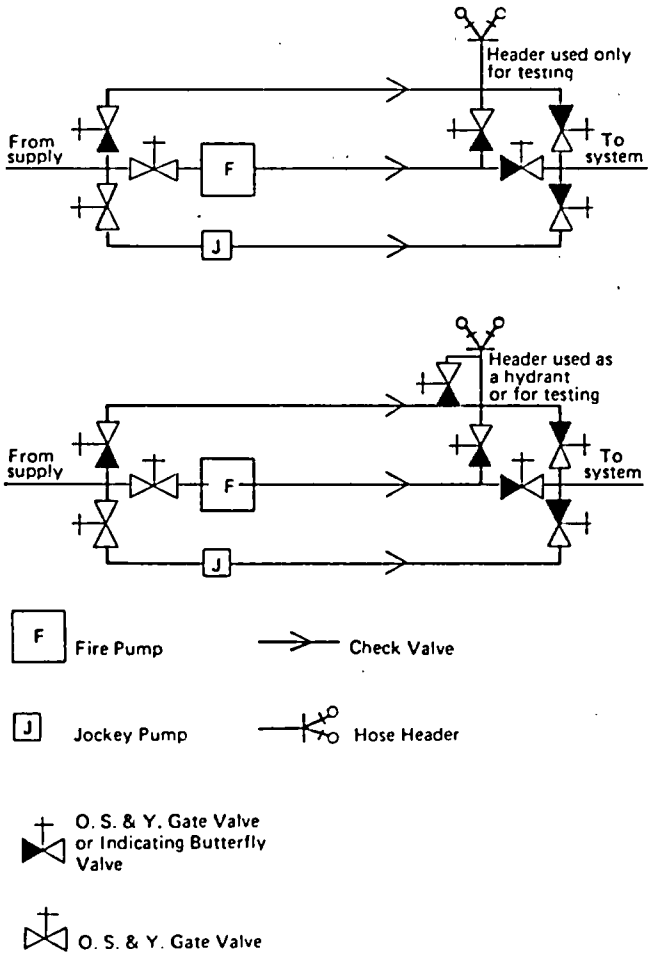


Figure A-2-9.5 Schematic Diagram of Suggested Arrangements for a Fire Pump with a Bypass, Taking Suction from Public Mains.

NOTE 1: A jockey pump is usually required with automatically controlled pumps.

NOTE 2: If testing facilities are to be provided, also refer to Figure A-2-13.2.1(a) and Figure A-2-13.2.1(b).

to move, without provisions for relieving the strain. Flexibility can be provided by the use of flexible couplings at critical points, and by allowing clearances at walls and floors. Fire pump suction and discharge pipes should be treated the same as sprinkler risers for whatever portion is within a building. (*See NFPA 13, A-3-10.3.*)

A-2-12.1 Holes through pump room fire walls should be packed with mineral wool or other suitable material held in place by pipe collars on each side of the wall. Pipes passing through foundation walls or pit walls into ground should have clearance from these walls but holes should be watertight. Space around pipes passing through pump room walls or pump house floors may be filled with asphalt mastic.

A-2-13.6 The relief valve cone should be piped to a point where water can be freely discharged, preferably outside the building. If the relief valve discharge pipe is connected to an

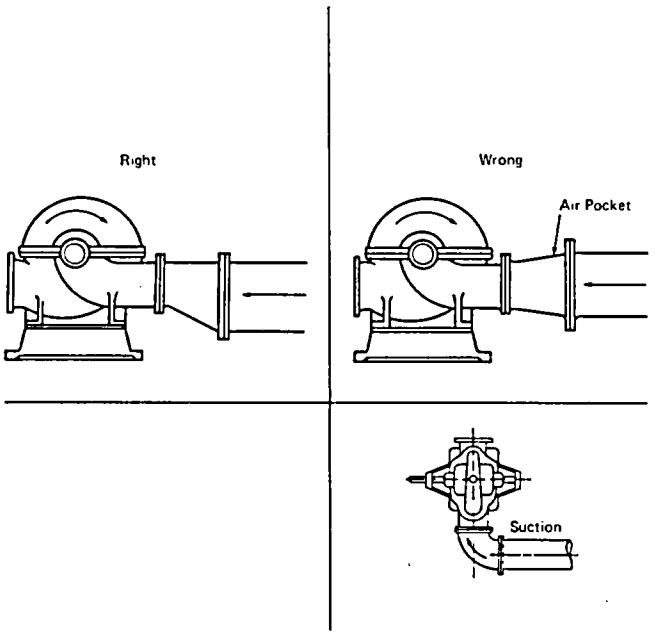


Figure A-2-9.6 Right and Wrong Pump Suctions.
See *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*, Thirteenth Edition, for additional information.

underground drain, care should be taken that no steam drains enter near enough to work back through the cone and into the pump room.

A-2-13.9 When the relief valve discharges back to the source of supply, the back pressure capabilities and limitations of the valve to be used should be determined. It may be necessary to increase the size of the relief valve and piping above the minimum, to obtain adequate relief capacity due to back pressure restriction.

A-2-14.1.2 Outlets can be provided through the use of standard test headers, yard hydrants, wall hydrants or standpipe hose valves.

NOTE 1: Distance as recommended by the meter manufacturer.

NOTE 2: Distance as recommended by the meter manufacturer.

NOTE 3: Distance not less than five diameters of suction pipe for top or bottom suction connection. Distance not less than ten diameters of suction pipe for side connection (not recommended).

NOTE 4: Automatic air release if piping forms an inverted "U," trapping air.

NOTE 5: The fire protection system should have outlets available to test the fire pump and suction supply piping. (*See A-2-13.1.2.*)

NOTE 6: The closed loop meter arrangement will only test net pump performance. It does not test the condition of the suction supply, valves, piping, etc.

NOTE 7: Return piping should be so arranged that no air can be trapped that would eventually end up in the eye of the pump impeller.

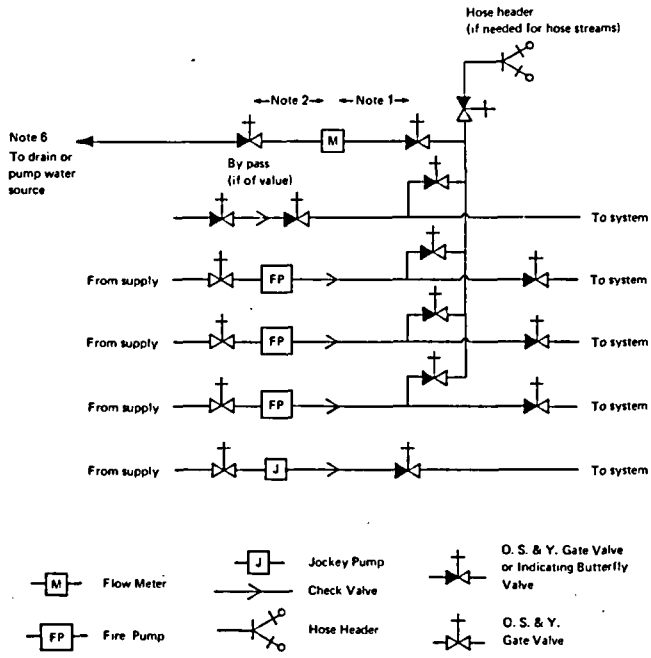


Figure A-2-14.2.1(a) Diagram of Preferred Arrangement for Measuring Fire Pump Water Flow with Meter for Multiple Pumps and Water Supplies, Water Discharge to Drain or to Pump Water Source.

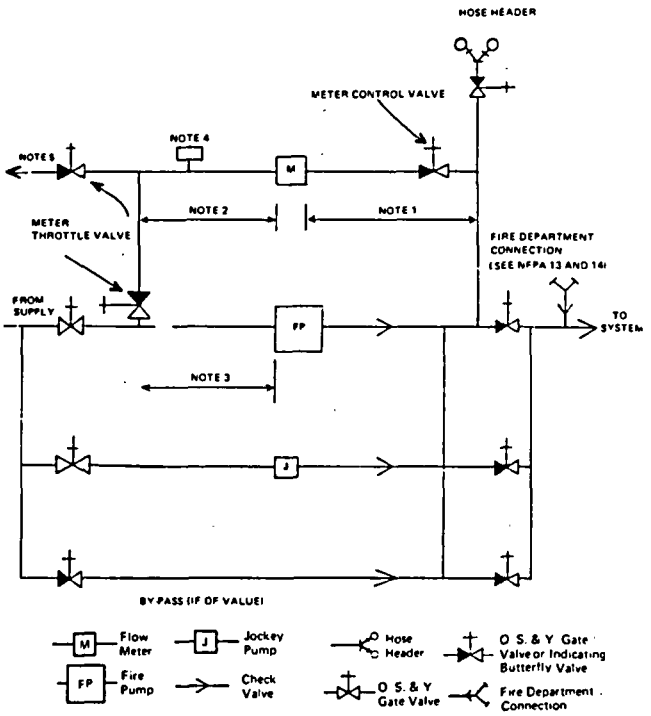


Figure A-2-14.2.1(b) Diagram of Typical Arrangement for Measuring Fire Pump Water Flow with Meter, Discharge to Pump Suction.

NOTE 8: Turbulence in the water entering the pump must be avoided to eliminate cavitation that would reduce pump discharge and damage the pump impeller. For this reason, side connection is not recommended.

NOTE 9: Prolonged recirculation can cause damaging heat buildup, unless some water is wasted.

NOTE 10: Flow meter must be installed according to manufacturer's instructions.

A-2-14.2.1 Metering devices should discharge to drain.

Exception: In the case of a limited water supply, the discharge should be back to the water source (suction tank, small pond, etc.). If this discharge enters the source below minimum water level, it is not likely to create an air problem for the pump suction. If it enters over the top of the source, the air problem is reduced by extending the discharge to below the normal water level.

A-2-14.3.1 The hose valves should be attached to a header or manifold and connected by suitable piping to the pump discharge piping. The connection point should be between the discharge check valve and the discharge gate valve. Hose valves should be located to avoid any possible water damage to the pump driver or controller, and they should be outside the pump room or pump house. If there are other adequate pump testing facilities, the hose valve header may be omitted when its main function is to provide a method of pump and suction supply testing. When the hose header also serves as the equivalent of a yard hydrant, this omission should not reduce the number of hose valves to less than two.

A-2-17 (a) *Rotation of Pumps.* Pumps are designated as having right-hand or clockwise (CW) rotation, or left-hand or counter clockwise (CCW) rotation. Diesel engines are commonly stocked and supplied with clockwise rotation.

(b) *Horizontal Pump Shaft Rotation.* The rotation of a horizontal pump can be determined by standing at the driver end and facing the pump. If the top of the shaft revolves from the left to the right, the rotation is right-hand or clockwise (CW). If the top of the shaft revolves from right to left, the rotation is left-hand or counter clockwise (CCW).

(c) *Vertical Pump Shaft Rotation.* The rotation of a vertical pump can be determined by looking down upon the top of the pump. If the point of the shaft directly opposite revolves from left to right, the rotation is right-hand or clockwise (CW). If the point of the shaft directly opposite revolves from right to left, the rotation is left-hand or counterclockwise (CCW).

A-2-18 In addition to those conditions which require alarm signals for pump controllers and engines, there are other conditions for which such alarms might be recommended, depending upon local conditions. Some of these supervisory alarm conditions are:

(a) Low pump room temperature.

(b) Relief valve discharge.

(c) Flow meter left "on," bypassing the pump.

(d) Water level in suction supply below normal.

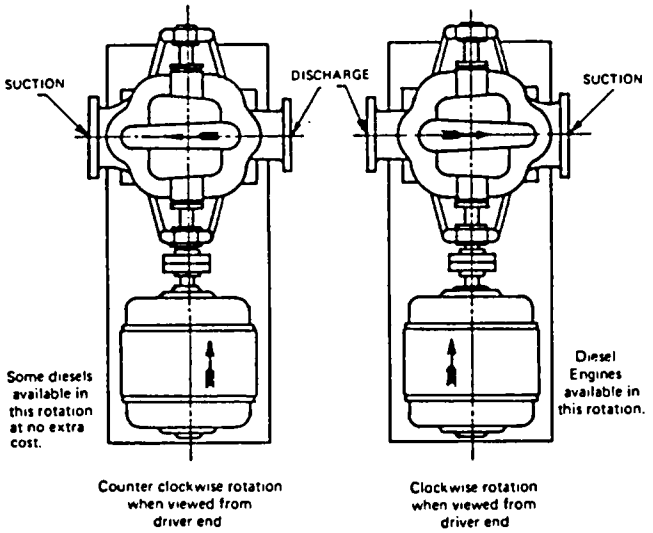


Figure A-2-17(b) Horizontal Pump Shaft Rotation.

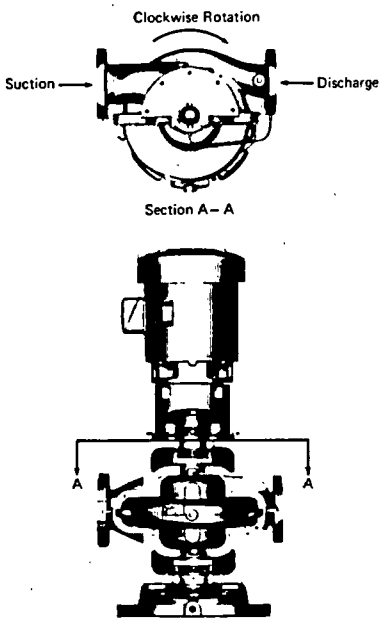


Figure A-2-17(c) Vertical Pump Shaft Rotation.

(e) Water level in suction supply near depletion.

(f) Diesel fuel supply below normal.

(g) Steam pressure below normal.

Such additional alarms may be incorporated into the trouble alarms already provided on the controller, or they may be independent.

A-2-19 Pressure maintenance (jockey or make-up) pumps should be used when it is desirable to maintain a uniform or relatively high pressure on the fire protection system. A jockey pump should be sized to make up the allowable leakage rate within 10 minutes, or 1 gpm (3.8 L/min), whichever is larger.

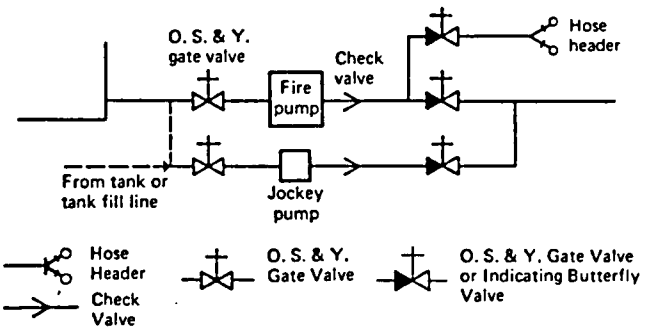


Figure A-2-19.3 Jockey Pump Installation with Fire Pump.

NOTE 1: A jockey pump is usually required with automatically controlled pumps.

NOTE 2: Jockey pump suction may come from the tank filling supply line. This would allow high pressure to be maintained on the fire protection system even when the supply tank may be empty for repairs.

A-2-19.4 A centrifugal-type pressure maintenance pump is preferable.

A-3-2.1 Listed pumps can have different head capacity curve shapes for a given rating. Figure A-3-2.1 illustrates the extremes of the curve shapes probable. Shutoff head will range from a minimum of 101 percent to a maximum of 140 percent of rated head. At 150 percent of rated capacity, head will range from a minimum of 65 percent to a maximum of just below rated head. Pump manufacturers can supply expected curves for their listed pumps.

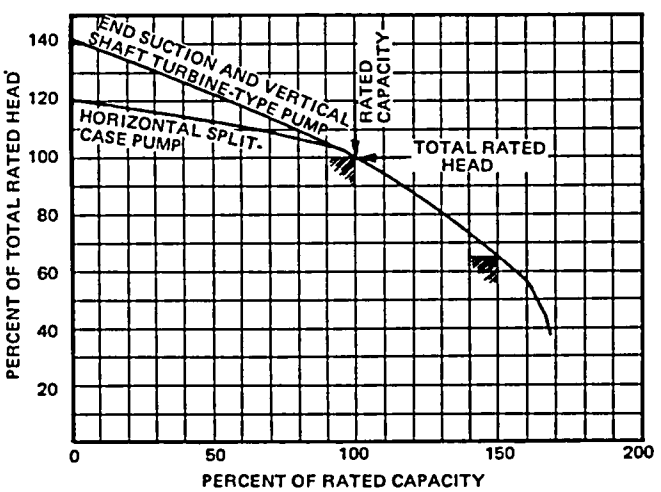
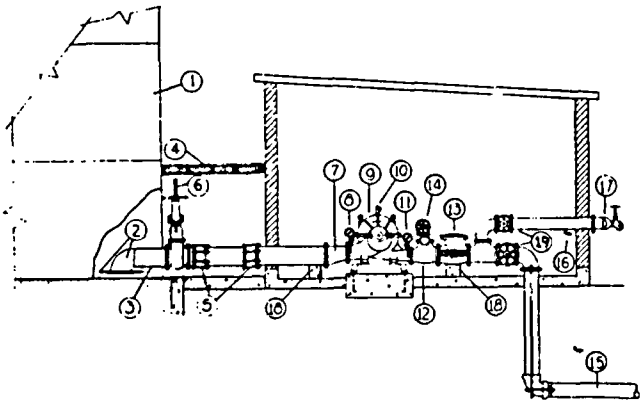


Figure A-3-2.1 Pump Characteristic Curves.

A-3-4.3 A substantial foundation is important in maintaining alignment. The foundation should preferably be made of reinforced concrete.

A-3-5 If pumps and drivers were shipped from the factory with both machines mounted on a common base plate, they were accurately aligned before shipment. All base plates are flexible to some extent and, therefore, must not be relied upon to maintain the factory alignment. Realignment is necessary after the complete unit has been leveled on the foundation and again after the grout has set and foundation bolts



1. Aboveground suction tank.
2. Entrance elbow and 4 ft × 4 ft (1.2 m × 1.2 m) square vortex plate. Distance above bottom of tank — one-half diameter of suction pipe with a minimum of 6 in. (152 mm).
3. Suction pipe.
4. Frostproof casing.
5. Flexible couplings for strain relief.
6. O.S.&Y. gate valve (*see 2-9.7 and A-2-9.7*).
7. Eccentric reducer.
8. Suction gage.
9. Horizontal split-case fire pump.
10. Automatic air release.
11. Discharge gage.
12. Reducing discharge tee.
13. Discharge check valve.
14. Relief valve (if required).
15. Discharge pipe.
16. Drain valve or ball drip.
17. Hose valve manifold with hose valves.
18. Pipe supports.
19. Indicating gate or indicating butterfly valve.

Figure A-3-3.1 Horizontal Split-Case Fire Pump Installation with Water Supply under a Positive Head.

have been tightened. The alignment should be checked after the unit is piped and rechecked periodically. To facilitate accurate field alignment, most manufacturers either do not dowel the pumps or drivers on the base plates before shipment, or at most dowel the pump only.

After the pump and driver unit has been placed on the foundation the coupling halves should be disconnected. The coupling should not be reconnected until the alignment operations have been completed.

A flexible coupling should not be used to compensate for misalignment of the pump and driver shafts. The purpose of the flexible coupling is to compensate for temperature changes and to permit end movement of the shafts without interference with each other while transmitting power from the driver to the pump.

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

(a) Angular misalignment — shafts with axes concentric but not parallel.

(b) Parallel misalignment — shafts with axes parallel but not concentric.

The faces of the coupling halves should be spaced far enough apart so that they cannot strike each other when the driver rotor is moved hard over toward the pump. Due allowance should be made for wear of the thrust bearings. The necessary tools for an approximate check of the alignment of a flexible coupling are a straight edge and a taper gage or a set of feeler gages.

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

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

Angular and parallel misalignment are corrected by means of shims under the motor mounting feet. After each change, it is necessary to recheck the alignment of the coupling halves. Adjustment in one direction may disturb adjustments already made in another direction. It should not be necessary to adjust the shims under the pump.

The permissible amount of misalignment will vary with the type of pump and driver.

The best method for putting the coupling halves in final accurate alignment is by the use of a dial indicator.

When the alignment is correct, the foundation bolts should be tightened evenly but not too firmly. The unit can then be grouted to the foundation. The base plate should be completely filled with grout, and it is desirable to grout the leveling pieces, shims, or wedges in place. Foundation bolts should not be fully tightened until the grout is hardened, usually about 48 hours after pouring.

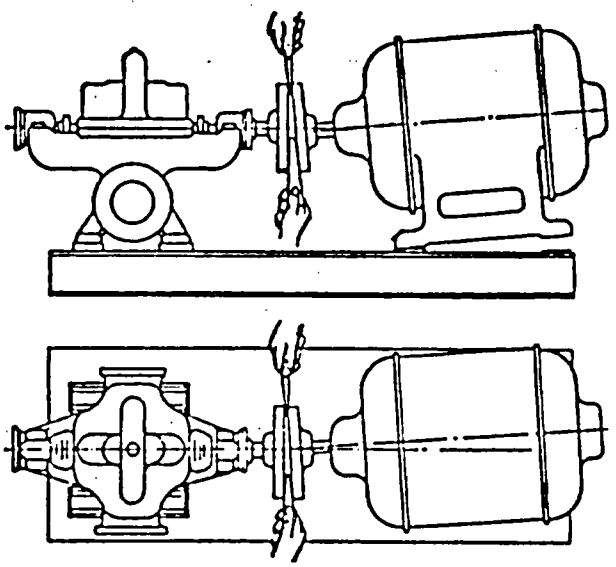
After the grout has set and the foundation bolts have been properly tightened, the unit should be checked for parallel and angular alignment and, if necessary, corrective measures taken. After the piping of the unit has been connected, the alignment should be checked again.

The direction of driver rotation should be checked to make certain that it matches that of the pump. The corresponding direction of rotation of the pump is indicated by a direction arrow on the pump casing.

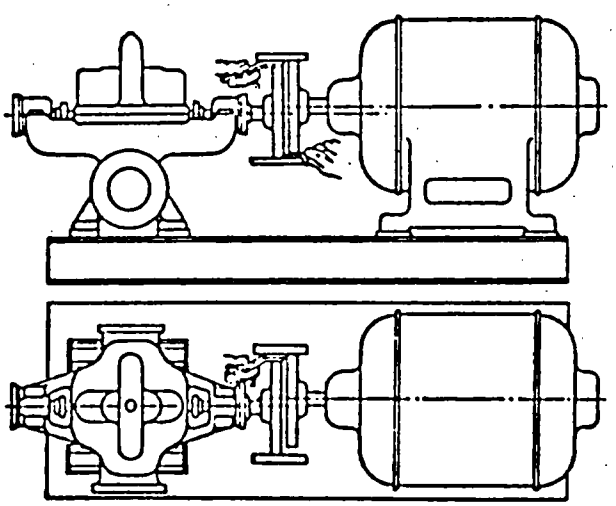
The coupling halves can then be reconnected. With the pump properly primed, the unit then should be operated under normal operating conditions until temperatures have stabilized. It then should be shut down and immediately checked again for alignment of the coupling. All alignment checks must be made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

After the unit has been in operation for about 10 hours or three months, the coupling halves should be given a final check for misalignment caused by pipe or temperature strains. If the alignment is correct, both pump and driver

should be dowelled to the base plate. Dowel location is very important and the manufacturer's instructions should be obtained, especially if the unit is subjected to temperature changes.



Checking Angular Alignment[1]



Checking Parallel Alignment

Figure A-3-5.[1]

The unit should be checked periodically for alignment. If the unit does not stay in line after being properly installed, the following are possible causes:

(a) Settling, seasoning, or springing of the foundation. Pipe strains distorting or shifting the machine.

(b) Wear of the bearings.

(c) Springing of the base plate by heat from an adjacent steam pipe or from a steam turbine.

(d) Shifting of the building structure due to variable loading or other causes.

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

A-4-1 Supervision of Installation. Satisfactory operation of vertical turbine-type pumps is dependent to a large extent upon careful and correct installation of the unit; therefore, it is recommended that this work be done under the direction of a representative of the pump manufacturer.

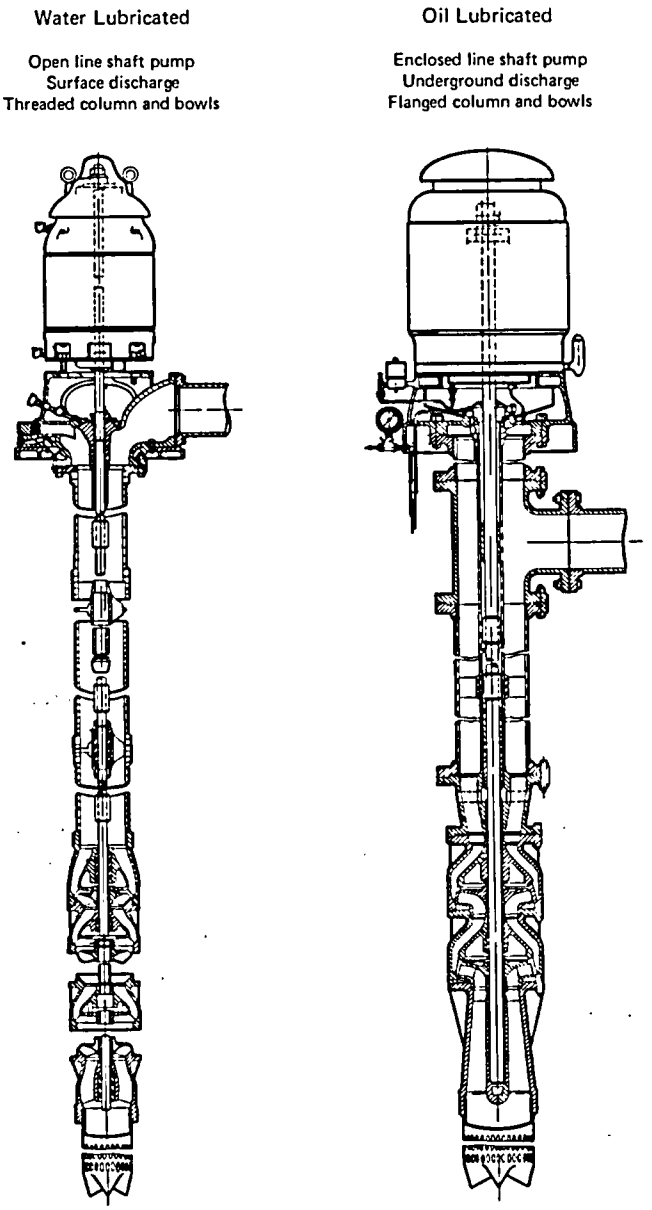


Figure A-4-1.1 Illustration of Water-Lubricated and Oil-Lubricated Shaft Pumps.

A-4-2.1.1 Water Supply Source. Stored water supplies from reservoirs or tanks supplying wet pits are preferable. Lakes, streams, and groundwater supplies are acceptable where investigation shows that they can be expected to provide a suitable and reliable supply.

[1]Diagram reprinted from *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. Copyright by the Hydraulic Institute, 1230 Keith Building, Cleveland, OH 44115.

A-4-2.1.2 Aquifer Performance Analysis. The authority having jurisdiction may require an aquifer performance analysis. The history of the water table should be carefully investigated. The number of wells already in use in the area and the probable number that may be in use should be considered in relation to the total amount of water available for fire protection purposes.

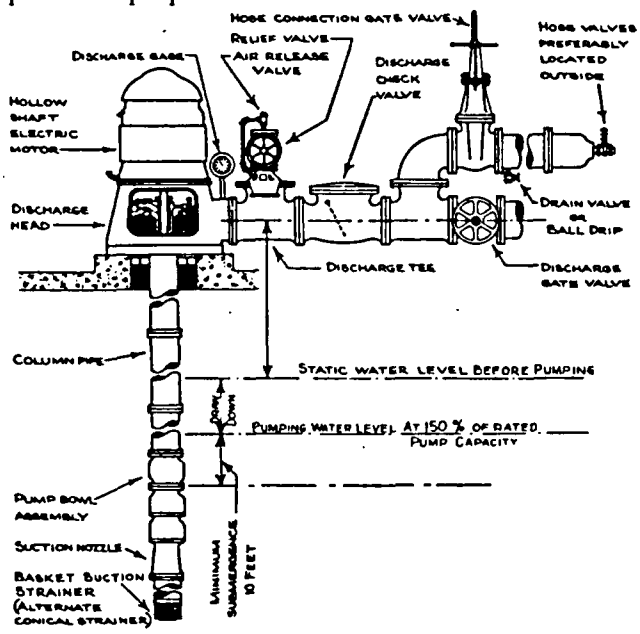


Figure A-4-2.2.1 Vertical Shaft Turbine-type Pump Installation in a Well.

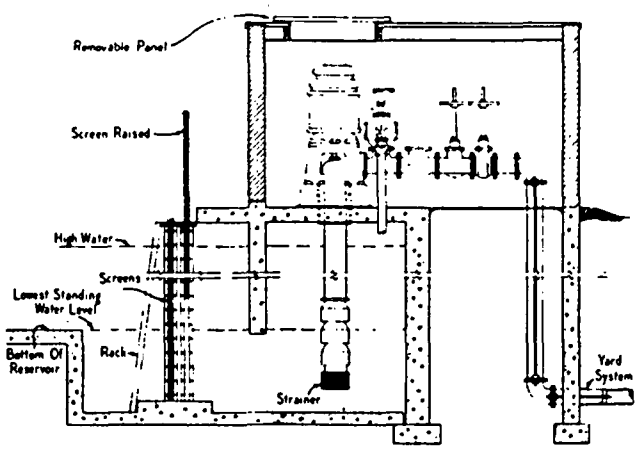


Figure A-4-2.2.2 Vertical Shaft Turbine-type Pump — Installation in a Wet Pit.

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

A-4-2.2.2 Intake Design. The function of the intake, whether it be an open channel or a tunnel having 100 percent wetted perimeter, is to supply an evenly distributed flow of water to the pump suction bell. An uneven distribution of flow, characterized by strong local currents, favors formation of vortices and with certain low values of submergence will introduce air into the pump with reduction of capacity, accompanied by noise. There may be vortices which do not appear on the surface and these also may have adverse effects.

The velocities in the approach channel and wet pit should not exceed approximately 1 ft/sec (0.3 m/sec).

The ideal approach is a straight channel coming directly to the pump. Turns and obstructions are detrimental since they may cause eddy currents and tend to initiate deep-cored vortices. The amount of submergence for successful operation will depend greatly on the approaches of the intake and the size of the pump.

The Hydraulic Institute Standards have recommended sump dimensions for flows 3000 gpm (11 355 L/min) and larger. The design of sumps for pumps with discharge capacities less than 3000 gpm (11 355 L/min) should be guided by the same general principles as shown in the Hydraulic Institute Standards.

A-4-2.5 Consolidated Formations. Where wells take their supply from consolidated formations, such as rock, the specifications for the well should be decided upon by the authority having jurisdiction after consultation with a recognized groundwater consultant in the area.

A-4-2.7 Test and Inspection of Well. Before the permanent pump is ordered, the water from the well should be analyzed for corrosiveness, including such items as pH, salts such as chlorides, harmful gases such as carbon dioxide (CO_2) or hydrogen sulfide (H_2S). If the water is corrosive, the pumps should be constructed of a suitable corrosion-resistant material or covered with special protective coatings in accordance with manufacturer's recommendations.

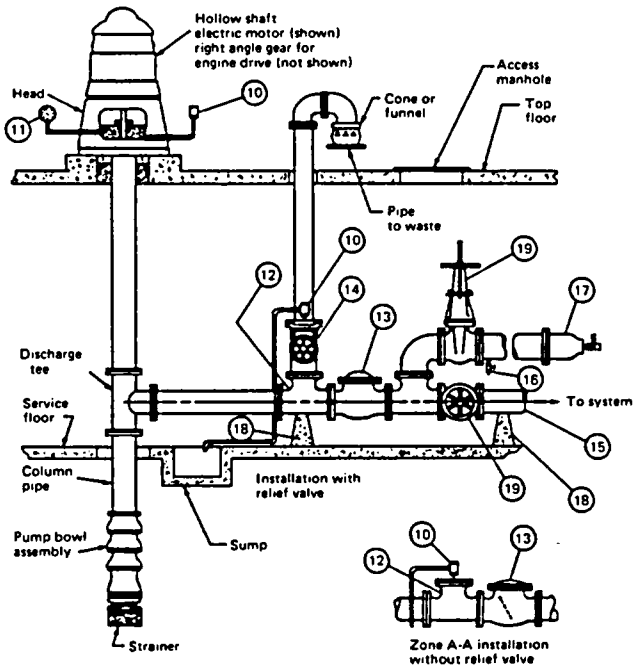
A-4-3.5.3 Air Line Method of Water Level Detection.

(a) A satisfactory method of determining the water level involves the use of an air line of small pipe or tubing and of known vertical length, a pressure or depth gage, and an ordinary bicycle or automobile pump installed as shown in Figure A-4-3.5.3. The air line pipe should be of known length and extend beyond the lowest anticipated water level in the well in order to assure more reliable gage readings, and should be properly installed. As noted in Figure A-4-3.5.3, an air pressure gage is used to indicate the pressure in the air line.

(b) The air line pipe is lowered into the well, a tee is placed in the line above the ground, and a pressure gage is screwed into one connection. The other connection is fitted with an ordinary bicycle valve to which a bicycle pump is attached. All joints must be made carefully and must be airtight to obtain correct information. When air is forced into the line by means of the bicycle pump, the gage pressure increases until all of the water has been expelled. When this point is reached the gage reading becomes constant. The maximum maintained air pressure recorded by the gage is equivalent to that necessary to support a column of water of the same height as that forced out of the air line. The length of this water column is equal to the amount of air line submerged.

(c) Deducting this pressure converted to ft (m) (psi pressure × 2.31 = ft, and bars pressure × 10.3 = m) from the known length of the air line will give the amount of submergence.

Example: The following calculation will serve to clarify Figure A-4-3.5.3.



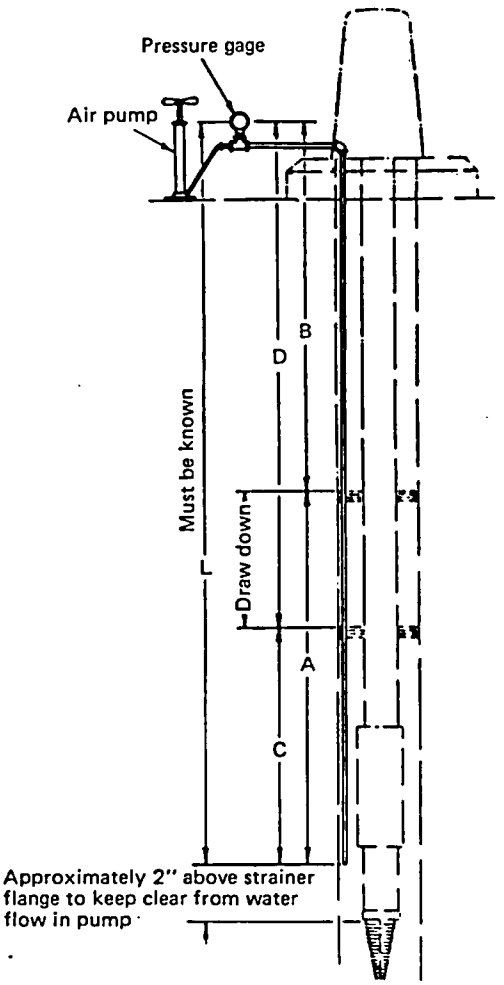
1. Aboveground suction tank.
2. Entrance elbow and 4 ft × 4 ft (1.2 m × 1.2 m) square vortex plate. Distance above bottom of tank — one-half diameter of suction pipe with a minimum of 6 in. (152 mm).
3. Suction pipe.
4. Frostproof casing.
5. Flexible couplings for strain relief.
6. O.S.&Y. gate valve (*see 2-9.7 and A-2-9.7*).
7. Eccentric reducer.
8. Suction gage.
9. Horizontal split-case fire pump.
10. Automatic air release.
11. Discharge gage.
12. Reducing discharge tee.
13. Discharge check valve.
14. Relief valve (if required).
15. Discharge pipe.
16. Drain valve or ball drip.
17. Hose valve manifold with hose valves.
18. Pipe supports.
19. Indicating gate or indicating butterfly valve.

Figure A-4-3.1 Below Ground Discharge Arrangement.

Assume a length (L) of 50 ft (15.2 m).

Pressure gage reading before starting fire pump (p_1) = 10 psi (0.68 bars). Then "A" = 10 × 2.31 = 23.1 ft (0.68 × 10.3 = 7.0 m); therefore, the water level in the well before starting the pump would be B = L – A = 50 – 23.1 = 26.9 ft (B = L – A = 15.2 – 7 = 8.2 m).

Pressure gage reading when pumping = (p_2) = 8 psi (0.55 bars). Then C = 8 × 2.31 = 18.5 ft (0.55 × 10.3 = 5.6 m); therefore, the water level in the well while pumping would be D = L – C = 50 – 18.5 ft = 31.5 ft (D = L – C = 15.2 m – 5.6 m = 9.6 m).



For SI Units: 1 ft = 0.3048 m.

Figure A-4-3.5.3 Air Line Method of Determining Depth of Water Level.

The drawdown may be determined by any of the following methods:

(a) D – B = 31.5 – 26.9 = 4.6 ft (9.6 m – 8.2 m = 1.4 m),

(b) A – C = 23.1 – 18.5 = 4.6 ft (7.0 m – 5.6 m = 1.4 m), or

(c) $p_1 - p_2$ = 10 – 8 = 2 psi = 2 × 2.31 – 4.6 ft (= 0.68 – 0.55 = 0.13 bar = 0.13 × 10.3 = 1.4 m).

A-4-4 Method of Erecting. Several methods of installing a vertical pump may be followed, depending upon the location of the well and facilities available. Since most of the unit is underground, extreme care must be used in assembling and installing it, and in thoroughly checking the work as it progresses. The following simple method is the most common:

1. Construct a tripod or portable derrick and use two sets of installing clamps over open well or pump house. After the derrick is in place the alignment should be checked carefully with the well or wet pit to avoid any trouble when setting the pump.

2. Attach set of clamps to the suction pipe on which strainer has already been placed and lower into the well until clamps rest on block beside well casing or on pump foundation.

3. Attach clamps to pump stage assembly and bring over well and install pump stages to suction pipe, etc., until each piece has been installed in accordance with manufacturer's instructions.

A-4-7.1.1 Setting Impellers. The setting of the impellers should be undertaken only by a representative of the pump manufacturer. Improper setting will develop excessive friction loss by rubbing of impellers on pump seals with resultant increase in power demand. If adjusted too high there will be a loss in capacity; and full capacity is vital for fire pump service. The top shaft nut should be locked or pinned after proper setting.

A-4-7.1.2 Vibration and Excessive Motor Temperature. Pumping units are checked at the factory for smoothness of performance and should operate satisfactorily on the job. If excessive vibration is present, several conditions may be causing the trouble: a bent pump or column shaft, impellers not properly set within the pump bowls, pump not hanging freely in the well, or strain transmitted through the discharge piping. Excessive motor temperature is generally caused either by a maintained low voltage of the electric service, or improper setting of impellers within the pump bowls.

A-6-2.2 A private generating plant located on the premises served by the fire pump is considered as a power station, if it is in a separate power house or cut off from the main buildings. It may be used as one of the two sources of current supply. Where two sources are used with automatic transfer switches, refer to NFPA 70, *National Electrical Code*, Article 700.

A-6-3.1.1 Where risks involved are large and interruption of fire pump service would seriously affect protection, at least two separate circuits from the power plant(s) to the pump room should be provided. The circuits should be run by separate routes or in such a manner that failure of more than one at the same time would be only a remote possibility.

A completely underground circuit from generating station to the pump room is strongly recommended and should be obtained when practicable. When such construction is not available, an overhead circuit may be allowed, but that part of the circuit adjacent to the plant served by the fire pump or to exposing plants should be run with special reference to damage in case of fire. Where the pump room is part of, or in close proximity to, the plant which the pump is designed to protect, the wires should be underground for some distance from the pump room.

A-6-3.3 Where the alternate power is from an on-site generator, the alternate service equipment need not be located in the fire pump room.

A-7-2.1 If the controller must be located outside of the pump room, a glazed opening should be provided in the pump room wall for observation of the motor and pump during starting. The pressure control pipe line should be protected against freezing and mechanical injury.

A-7-3.7.3 Pump operators should be familiar with instructions provided for controllers and should observe in detail all of their recommendations.

A-7-4.3.3 Attention should be given to the type of service grounding to establish circuit breaker interrupting rating based upon grounding type employed.

A-7-4.3.3(4) The interrupting rating may be less than the suitability rating when other devices within the controller assist in the current interrupting process.

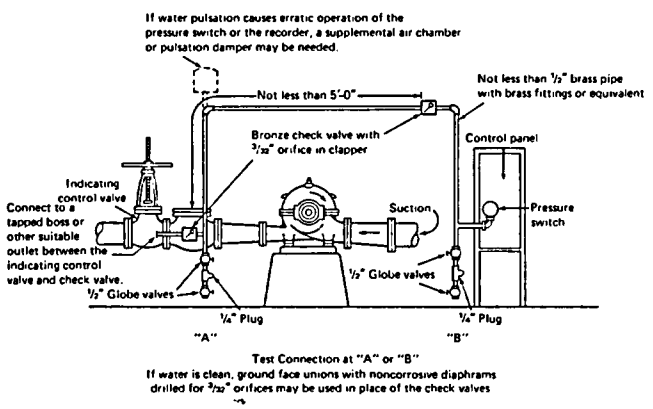
A-7-4.6 The pilot lamp for alarm and signal service should have operating voltage less than the rated voltage of the lamp to ensure long operating life. When necessary, a suitable resistor or potential transformer should be used to reduce the voltage for operating the lamp.

A-7-4.7(b) To supervise the power source for the alarm circuit, the controller may be arranged to start upon failure of the alarm circuit power.

A-7-5.1 The following definitions are from NFPA 70, *National Electrical Code*:

Automatic. Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

Nonautomatic. Nonautomatic means that the implied action requires personal intervention for its control. As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.



For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Figure A-7-5.2.1 Piping Connection for Each Automatic Pressure Switch (for Fire Pump and each Jockey Pumps).

NOTE: Solenoid drain valve used for engine driven fire pumps may be at "A," "B," or "inside of controller enclosure

A-7-6.1 Voltages in excess of 600 are not recommended for fire pump service. Where it is impracticable to use a low voltage, higher voltages may be accepted.

A-7-7 The authority having jurisdiction may permit the use of a limited service controller for special situations where such use is acceptable to said authority.

A-7-8.2.1 The compartmentalization or separation is to prevent propagation of a fault in one compartment to the source in the other compartment.

A-8-2.4.8 Terminations should be made using insulated ring-type compression connectors for post-type terminal blocks. Saddle type terminal blocks should have the wire stripped with about 1/16 in. of bare wire showing after insertion in the saddle to assure that no insulation is below the saddle. Wires should be tugged to assure adequate tightness of the termination.

A-8-2.4.9 Manual mechanical operation of the main battery contactor will bypass all of the control circuit wiring within the controller.

A-8-2.6.3 A single charger that automatically alternates from one battery to another may be used on two battery installations.

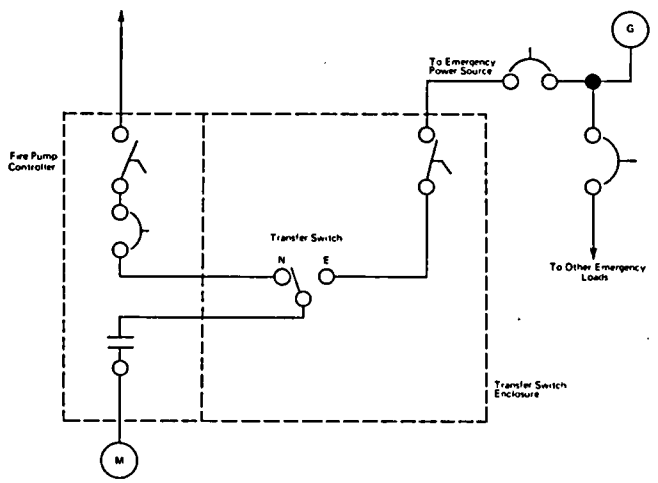
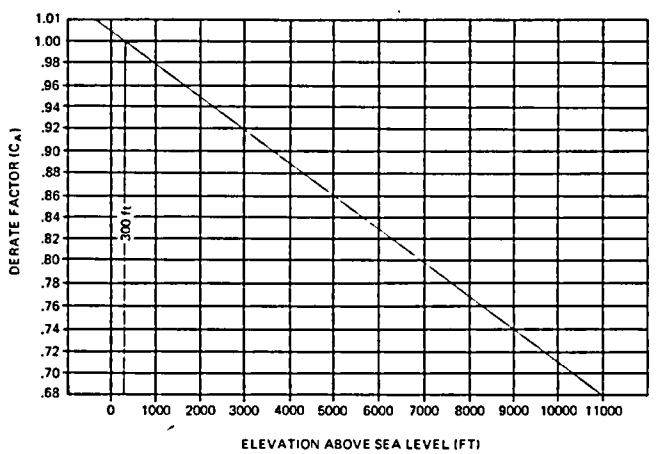
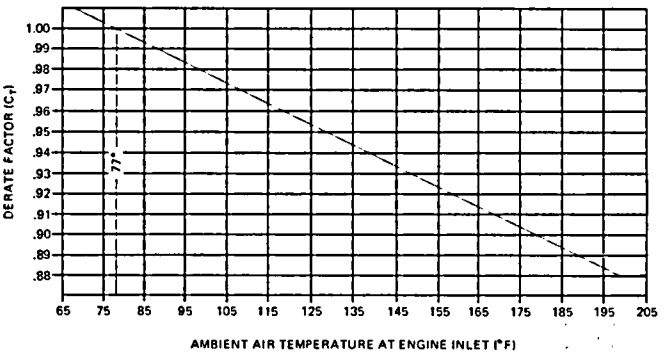


Figure A-7-8.2 One Method of Automatic Transfer Switch Installation for Two Power Sources.



For SI Units: 1 ft = 0.3048 m.

Figure A-8-2.2.4 Elevation Derate Curve.
(See note for Figure A-8-2.2.5.)



For SI Units: °C = (°F – 32) 5/9

NOTE: Correction Equation.

Corrected Engine Horsepower = Listed Engine Horsepower X (C_A + C_T × 1.0)

C_A = Derate Factor for Elevation

C_T = Derate Factor for Temperature

Figure A-8-2.2.5 Temperature Derate Curve.

A-8-2.6.5 Location at the side of and level with the engine is recommended to minimize lead length from battery to starter.

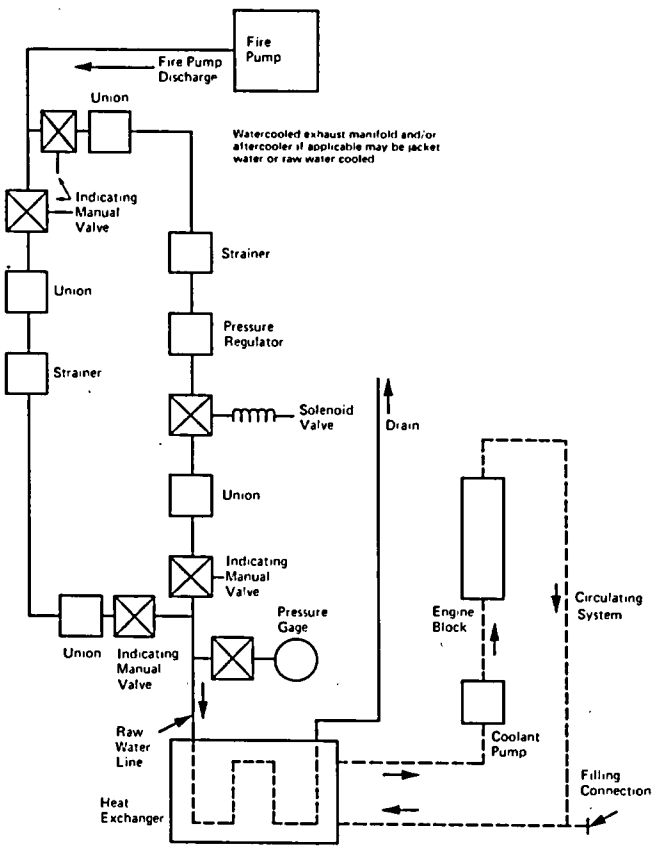


Figure A-8-2.7.2 Cooling Water Line with Bypass.