NFPA

20

ANSI/NFPA 20
An American
National
Standard
January 19, 1983

NFPA 20 CENTRIFUGAL FIRE PUMPS 1983

CENTRIFUGAL FIRE PUMPS 1983

NFPA®

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7.5M-2-83-FP-MP

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Errata

NFPA 20—1983

NFPA 20
Reference: Figure A-2-13.2.1(a)

The Technical Committee on Fire Pumps notes an error in the printing of NFPA 20—1983, *Standard for the Installation of Centrifugal Fire Pumps.* Figure A-2-13.2.1(a) was printed incorrectly. The correct figure follows:

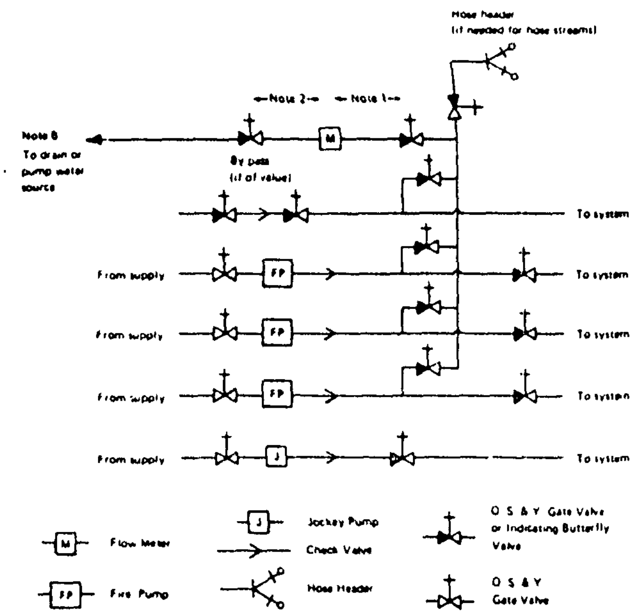

Figure A-2-13.2.1(a) Diagram of Preferred Arrangement for Measuring Fire Pump Water Flow with Meter for Multiple Pumps and Water Supplies, Water Discharge to Drain or to Pump Water Source.

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Standard for the Installation of

Centrifugal Fire Pumps

NFPA 20-1983

1983 Edition of NFPA 20

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 Related Equipment, and acted on by the National Fire Protection Association, Inc. on November 17, 1982, at its Fall Meeting in Philadelphia, Pennsylvania. It was issued by the Standards Council on January 19, 1983 with an effective date of February 12, 1983, and supersedes all previous editions.

The 1980 edition of this standard was approved by the American National Standards Institute as an American National Standard. This edition has also been submitted for similar approval.

Changes other than editorial are indicated by a vertical rule in the margin of the page 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 Mutuals, 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 usualy 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, and 1983.

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Contents

Chapter 1 Introduction 20-11
1-1 Scope 20-11
1-2 Purpose 20-11
1-3 Other Pumps 20-12
1-4 Approval Required 20-12
1-5 Unit Purchase 20-12
1-6 Certified Shop Test 20-12
1-7 Definitions 20-12
1-8 Units 20-19

Chapter 2 General 20-20
2-1 Water Supplies 20-20
2-2 Listed Pumps 20-20
2-3 Rated Pump Capacities 20-20
2-4 Nameplate 20-21
2-5 Pressure Gages 20-21
2-6 Circulation Relief Valve 20-21
2-7 Equipment Protection 20-21
2-8 Pipe and Fittings 20-22
2-9 Suction Pipe and Fittings 20-22
2-10 Discharge Pipe and Fittings 20-24
2-11 Protection of Piping Against Damage Due to Movement 20-25
2-12 Relief Valve 20-25
2-13 Water Measuring Devices 20-26
2-14 Power Supply Dependability 20-27
2-15 Shop Tests 20-27
2-16 Pump Shaft Rotation 20-28
2-17 Alarms 20-28
2-18 Gear Drive 20-28
2-19 Pressure Maintenance (Jockey or Make-up) Pumps 20-28
2-20 Summary of Fire Pump Data 20-28

Chapter 3 Horizontal Pumps 20-30
3-1 General 20-30
3-2 Factory and Field Performance 20-30
3-3 Fittings 20-30
3-4 Foundation and Setting 20-31
3-5 Alignment 20-31

Chapter 4 Vertical Shaft Turbine-type Pumps 20-32
4-1 General 20-32
4-2 Water Supply 20-32
4-3 Pump 20-35
4-4 Installation 20-37
4-5 Driver 20-38
4-6 Tests 20-39
4-7 Operation and Maintenance 20-39

Chapter 5 Fire Pumps for High-Rise Buildings 20-40
5-1 General 20-40
5-2 Pump 20-40
5-3 Installation 20-40
5-4 Driver 20-40
5-5 Controllers for Drivers 20-41
5-6 Tests 20-41
5-7 Unit Purchase 20-41

Chapter 6 Electric Drive for Pumps 20-42
6-1 General 20-42
6-2 Power Source(s) 20-42
6-3 Power Supply Lines 20-42
6-4 Transformers 20-44
6-5 Motors 20-45
6-6 Motor Application 20-46
6-7 Emergency Generator 20-46

Chapter 7 Electric Drive Controllers and Accessories 20-47
7-1 Application 20-47
7-2 Location 20-50
7-3 Construction 20-50
7-4 Components 20-51
7-5 Starting and Control 20-54
7-6 Controllers Rated in Excess of 600 Volts 20-57
7-7 Limited Service Controllers 20-58
7-8 Transfer Switches for Emergency Power Supply 20-59

Chapter 8 Diesel Engine Drive 20-62
8-1 General 20-62
8-2 Engines 20-62
8-3 Pump and Engine Protection 20-67
8-4 Fuel Supply and Arrangement 20-67
8-5 Engine Exhaust 20-68
8-6 Operation and Maintenance 20-68

Chapter 9 Engine Driven Controllers 20-70
9-1 General 20-70
9-2 Location 20-70
9-3 Construction 20-70
9-4 Components 20-71
9-5 Starting and Control 20-73

Chapter 10 Stean Turbine Drive 20-76
10-1 General 20-76
10-2 Turbine 20-76
10-3 Installation 20-78

Chapter 11 Acceptance, Operation and Maintenance 20-79
11-1 Hydrostatic Tests 20-79
11-2 Field Acceptance Tests 20-79
11-3 Annual Fire Pump Tests 20-81
11-4 Fire Pump Operation 20-82
11-5 Fire Pump Maintenance 20-82

Appendix A 20-83

Appendix B 20-122

Appendix C 20-129

Index 20-131

Standard for the Installation of
Centrifugal Fire Pumps

NFPA 20-1983

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 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 not be purchased until conditions under which they are to be installed and used have been determined.

1-4.2 * The pump manufacturer shall be given complete information concerning the water and power supply characteristics.

1-4.3 Prior to shipment of new equipment or alteration of existing equipment, a complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and water supply conditions shall be prepared by the engineer or contractor 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 Purchase.

1-5.1 The pump, driver, and controller shall be purchased under unit contract stipulating compliance with this standard and satisfactory performance of the entire unit when installed. (*For replacement components, see Chapter 11.*)

1-5.2 The pump manufacturer shall be responsible for the proper operation of the complete unit assembly, as indicated by field acceptance tests. (*See Section 11-2.*)

1-6 Certified Shop Test. Certified shop test curves showing head-capacity, efficiency, 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 Means. 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 Electric Motors. Electric motors are classified according to mechanical protection and methods of cooling.

1-7.2.1 Open Motor. An open motor is one having ventilating openings which 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.

1-7.2.2 Dripproof Motor. A dripproof motor is an open motor in which the ventilating openings are so constructed that successful operation is not interferred 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.

1-7.2.3 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.

1-7.2.4 Dripproof Guarded Motor. A dripproof guarded motor is a dripproof machine whose ventilating openings are guarded in accordance with 1-7.2.2.

1-7.2.5 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.

1-7.2.6 Totally Enclosed Nonventilated Motor. A totally enclosed nonventilated motor is a totally enclosed motor which is not equipped for cooling by means external to the enclosing parts.

1-7.2.7 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.

1-7.2.8 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 which 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 which may occur within the motor casing.

1-7.2.9 Dust-Ignition-Proof. A dust-ignition-proof motor is a totally enclosed motor whose enclosure is designed and constructed in a manner which will exclude ignitable amounts of dust or amounts which might affect performance or rating, and which 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.

1-7.3 Electric Supply.

1-7.3.1 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®*.)

1-7.3.2 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.*)

1-7.3.3 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.*)

1-7.3.4 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.*)

1-7.4 Engines.

1-7.4.1 Internal Combustion Engine. Any engine in which the working medium consists of the products of combustion of the air and fuel supplied. This combustion is usually effected within the working cylinder but may take place in an external chamber.

1-7.4.2 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.

1-7.5* Head.

1-7.5.1 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:

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

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

1-7.5.2 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)

1-7.5.3 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.

1-7.5.4 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.

1-7.5.5 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.

1-7.5.6 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.

1-7.5.7* 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.

1-7.5.8* Total Head (Symbol H), Vertical Turbine Pumps. Total head is the distance from the water level to the center of the discharge gage, plus the discharge pressure gage reading measure just beyond the discharge elbow and referred to datum, plus the velocity head at point of gage attachment.

1-7.5.9 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.

1-7.5.10 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.

1-7.6 Pumps.

1-7.6.1 Centrifugal Pump. A pump in which the pressure is developed principally by the action of centrifugal force.

1-7.6.2 End Suction Pump. A 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.

1-7.6.3 Fire Pump Unit. An assembled unit consisting of a fire pump, driver, controller and accessories.

1-7.6.4 Horizontal Pump. A pump with the shaft normally in a horizontal position.

1-7.6.5 Horizontal Split-case Pump. A centrifugal pump characterized by a housing which is split parallel to the shaft.

1-7.6.6 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.

1-7.6.7 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.

1-7.7 Water Supply for Vertical Shaft Turbine-type Pump.

1-7.7.1 Aquifer. An underground formation that contains sufficient saturated permeable material to yield significant quantities of water.

1-7.7.2 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.

1-7.7.3 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.

1-7.7.4 Ground Water. That water which is available from a well driven into water-bearing subsurface strata (aquifer).

1-7.7.5 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 center line of the discharge head or tee.

1-7.7.6 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 1-7.7.5.

1-7.7.7 Draw-Down. The vertical difference between the pumping water level and the static water level.

1-7.8 Official NFPA Definitions.

1-7.8.1 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.

1-7.8.2 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."

1-7.8.3 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.

1-7.8.4 Shall. Indicates a mandatory requirement.

1-7.8.5 Should. Indicates a recommendation or that which is advised but not required.

1-7.8.6 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.

1-7.9 Additional Definitions. Additional applicable definitions may be found in the latest edition of *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.*

1-8 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 1-8 with conversion factors.

Table 1-8

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.

1-8.1 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.

1-8.2 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 pump. This head shall be as indicated by a flow test.

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

2-3 Rated Pump Capacities.

2-3.1* Fire pumps shall have the following rated capacities in gpm and L/min, or larger, and are rated at net pressures of 40 psi (2.7 bars) or more.

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. It shall have a pressure range of at least twice the rated working pressure of the pump but not less than 200 psi (13.6 bars).

2-6 Circulation Relief Valve. Each pump shall be provided with an automatic relief valve set below the shutoff pressure at minimum expected suction pressure. It shall provide circulation of sufficient water to prevent the pump from overheating when operating with no discharge. A ¾-in. automatic relief valve shall be used for pumps with a rated capacity not to exceed 2500 gpm (9462 L/min); a 1-in. automatic relief valve shall be used for pumps with a rated capacity of 3000 to 4500 gpm (11 355 to 17 032 L/min). Provision shall be made for a discharge to a drain.

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 which 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 and/or multiple pumps (arranged to operate simultaneously) shall be such that with all pumps operating at 150 percent of rated capacity the net positive suction head (NPSH) available at the pump suction flange shall be at least 19 ft (5.8 m) absolute for horizontal split-case and end suction pumps. The NPSH available shall be decreased 1 ft (0.305 m) for each 1000 ft (305 m) above sea level at the pump installation. The suction pipe size shall not be less than shown in Table 2-20.

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 under water.

(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 mm²) 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 or copper 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.

2-10 Discharge Pipe and Fittings.

2-10.1 The discharge assembly 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 assembly 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 2-20.

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* Protection of Piping Against Damage Due to Movement.

2-11.1* A clearance of not less than 1 in. (25.4 mm) shall be provided around pipes which pass through walls or floors.

2-12 Relief Valve.

2-12.1 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.

2-12.2 The relief valve shall be set to prevent pressure on the fire protection system greater than it can withstand.

2-12.3 The relief valve size shall not be less than that given in Table 2-20. (*Refer also to 2-12.9 and A-2-12.9 for conditions affecting size.*)

2-12.4 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.

2-12.5 Pressure relief valves are of two types: the spring loaded and the pilot operated diaphragm type.

2-12.5.1 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.

2-12.6* 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.

2-12.7 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.

2-12.8 The relief valve discharge pipe from an open cone shall be of a size not less than that given in Table 2-20. If the pipe employs more than one elbow, the next larger pipe size shall be used.

2-12.9* 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.

2-12.10 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.

2-12.11 A shutoff valve shall not be installed in the relief valve supply or discharge piping.

2-13 Water Measuring Devices.

2-13.1 General.

2-13.1.1 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.

2-13.1.2* 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*).

2-13.2 Meters.

2-13.2.1* 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.

2-13.2.2 All of the meter system piping shall be sized as specified by the meter manufacturer but not less than the meter device sizes shown in Table 2-20.

2-13.2.3 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 meter and piping shall be used to minimize friction loss. The primary element shall be suitable for that pipe size and pump rating. The readout instrument shall be sized for the pump rated capacity. (*See Table 2-20.*)

2-13.3 Hose Valves.

2-13.3.1* Hose valves shall be listed. The number and size of hose valves used for pump testing shall be as specified in Table 2-20.

Exception: When the pipe between the detachable hose 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.

2-13.3.2 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.

2-13.3.3 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 header. The valve shall be at a point in the line close to the pump. (*See Figure A-3-3.1.*)

2-14 Power Supply Dependability.

2-14.1 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 which might threaten the property.

2-14.2 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 which might threaten the property.

2-15 Shop Tests.

2-15.1 Each individual pump shall be tested at the factory to provide detailed performance data and to demonstrate its compliance with specifications.

2-15.2 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 be not less than one and one-half times the head capabilities of the maximum diameter impeller for the casing at shutoff, plus the manufacturer's maximum allowable suction head but in no case 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.

2-16* Pump Shaft Rotation. Pump shaft rotation shall be determined and correctly specified when ordering fire pumps and equipment involving that rotation.

2-17* Alarms. Various sections of this standard specify alarms to call attention to improper conditions that may exist in the complete fire pump equipment.

2-18 Gear Drive. All gear drives shall be rated by the manufacturer at a load equal to the maximum horsepower and thrust of the pump for which the gear drive is intended.

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 2-20.*)

Table 2-20 Summary of Fire Pump Data

	Minimum 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 (378)	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 (1135)	4	4	2½	3½	4½	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

Chapter 3 Horizontal Pumps

3-1 General.

3-1.1 Types. Horizontal pumps shall be of split-case or end suction design. End suction pumps shall be single stage, centerline discharge design manufactured to American National Standards Institute, Inc., Standard B73.1, *Specifications for Horizontal End Suction Centrifugal Pumps for Chemical Process* with capacities under 500 gpm (1982 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 120 percent of rated head for split-case pumps, nor 140 percent for end suction pumps. (*See Figure A-3-2.1.*)

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. (Split-case pumps only.)

(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.

(e) Splash shield between pump and motor.

3-3.3 Automatic Air Release. Split-case 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 which 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 when 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. From this information the available discharge pressure at the discharge flange of the vertical pump can be determined. (*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 jurisdiction.

4-2.1.2* The acceptance of a well as a water supply source shall be dependent upon satisfactory development of the well and establishment of satisfactory aquifer characteristics. (*See Section 1-7 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 1,000 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 13th edition *Standards for Centrifuges, Rotary and Reciprocating Pumps.*

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 in the contractor's opinion best meet the conditions. Both inner and outer casing shall have a minimum wall thickness of .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, in the contractor's opinion, 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 .15 ft (46 mm) per second. The screen shall be made of a corrosion- and acid-resistant material, such as stainless steel, monel or fiberglass; fiberglass or monel shall be used where it is anticipated that the chloride content of the well water will exceed 1,000 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 for not less than 6 in. (152 mm) surrounding the well screen 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 1,000-ft (305-m) radius of the fire well shall be monitored throughout the test period.

4-3 Pump.

4-3.1 Head. The pump head shall be either the aboveground or belowground discharge type. It shall be designed to support the driver, pump column, and the oil tube tension nut or packing container.

4-3.2 Column.

4-3.2.1 The pump column shall be furnished in sections not exceeding a nominal length of 10 ft (3 m), shall be not less than the weight specified in Table 4-3.2, 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.

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.

4-3.4 Suction Strainer.

4-3.4.1 A cast or heavy fabricated, nonferrous 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 2-12.1.

Hose valve head and hose valves as specified in 2-13.3 or metering devices as specified in 2-13.2.

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 there 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 airline is used it shall be metallic such as copper. Airline 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 ofimpellers 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 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.

4-5.1.4 Where horizontal diesel engines are used, it shall be the responsibility of the pump manufacturer to furnish a universal joint coupling of suitable design which 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 of this standard or Engine Drive Controllers in Chapter 9.

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, representative of the pump manufacturer, 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*, Chapters 2 and 8; and to NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, Chapter 5 and Chapter 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 2-15.2.

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, 2-13, 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 2-15.

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, pump and controller representatives, 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.

5-7 Unit Purchase. Pumps, drivers, controllers and all necessary attachments shall be purchased under unit contracts, stipulating compliance with this standard and satisfactory performance of the entire unit when installed.

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 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 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 pumps are being driven at rated output, pressure and speed, and the lines between the power source and motors are carrying their peak load.

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.

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

Exception: The isolating 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 motors(s), jockey pump and associated fire pump accessory equipment.

Exception: Emergency power source feeder protection shall be per 6-7.4.

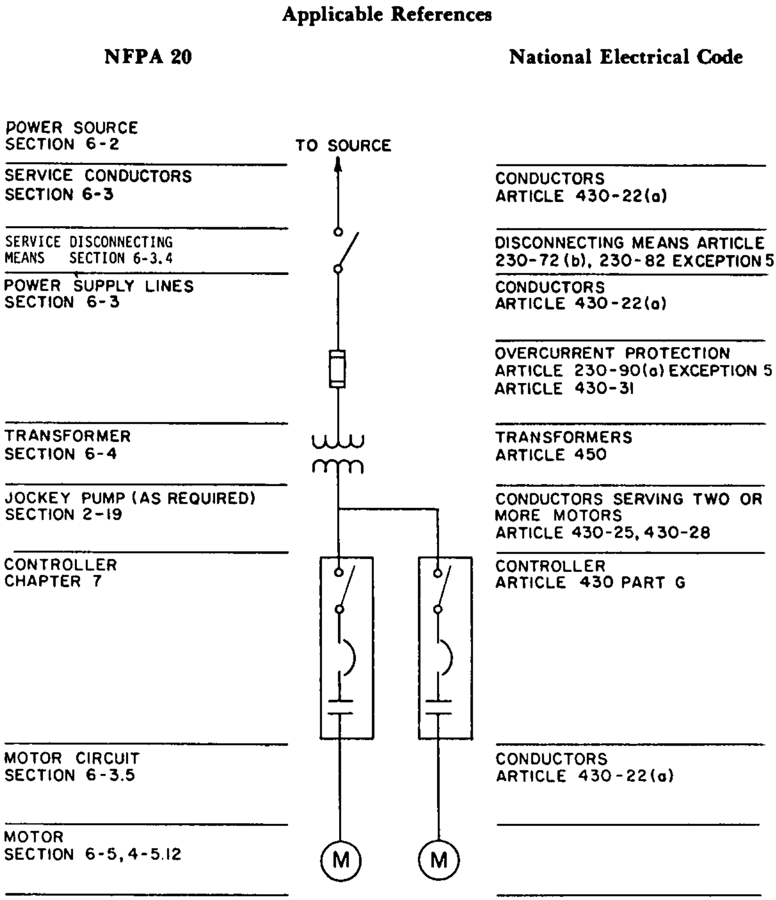


Figure 6-3.2 Power Supply from Source to Motor

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* All motors shall be rated for continuous duty and shall not be used at voltages exceeding 110 percent of rated voltage. It is the responsibility of the pump manufacturer to provide a motor of ample size as specified in 6-5.2. Alternating-current motors shall comply with the requirements in 6-5.1.1.

6-5.1.1 Squirrel-cage induction motors shall have normal starting and breakdown torque. The locked rotor current of three-phase, constant speed, induction motors, measured with rated voltage and frequency impressed with rotor locked, shall not exceed the values in Table 6-5.1.1.

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 230 volts.

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: For motors having a service factor stamped on the nameplate, the full load ampere rating is considered increased as permitted by the service factor.

6-5.2.2 Motors used at altitudes above 3,300 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, Section 430-7.

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 Emergency Generator.

6-7.1* Where emergency generators are used to supply power to fire pumps 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 Transfer of power shall take place within the pump room.

6-7.3 Conductors between transfer switch and emergency source shall comply with Section 6-3.

6-7.4 Protective devices in the emergency power source circuits at the generator shall allow instantaneous pick-up of the full pump room electric 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) Any controller selected shall have a short-circuit current withstand rating at least equal to the available short-circuit current for the circuit in which it is used.

(b) Short-circuit current at the controller shall be determined by using Table 7-1.1.1 when the installation meets the criteria established in the notes to the table. Otherwise, a short-circuit study must 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 completely assembled, wired, and tested by the manufacturer before shipment from the factory.

7-1.1.3 All controllers shall be marked "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 a 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.

Table 7-1.1.1 Interrupting Rating of Circuit Breakers of Fire Pump Controllers When Supplied Through Transformers

Transformer KVA	Transformer Secondary Volts	Circuit Breaker Interrupting Rating Amperes Symmetrical	Minimum Length of Cable Between Transformer and Circuit Breaker† ft MCM‡ 750	600	500	400	350	300	250	AWG‡ 4/0	3/0	2/0	1/0	1	2	4
750	600	14,000	52	50	48	45	42	39	36	34	33	31	30	27	25	17
	480	22,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	240	25,000	40	39	38	36	35	32	30	28	26	23	20	15	25	10
1,000	600	14,000	161	155	153	140	134	130	124	119	107	94	83	71	60	42
	480	22,000	50	45	39	35	32	31	30	28	26	24	22	20	19	12
	240	25,000	58	55	53	50	47	45	42	39	35	31	27	23	19	13
1,500	600	14,000	272	260	250	234	225	213	196	185	164	143	123	103	87	58
	480	22,000	110	106	102	96	92	88	82	77	69	61	53	45	38	26
	240	25,000	74	71	68	64	61	57	53	49	44	37	32	27	22	15
	600	22,000	93	89	86	83	81	77	73	69	63	56	49	42	36	26
	480	30,000	43	41	40	38	37	36	34	32	30	27	24	21	18	13
	240	42,000	33	31	30	28	26	24	23	21	19	17	15	13	11	8
2,000	600	14,000	325	310	298	280	265	252	231	216	190	164	140	117	97	65
	480	22,000	145	138	125	125	119	114	105	98	87	76	66	55	46	31
	240	25,000	83	79	76	71	67	63	58	54	47	41	35	29	24	16
	600	22,000	150	145	138	130	124	119	111	104	93	82	71	60	51	34
	480	30,000	79	76	74	70	67	64	60	56	50	44	38	33	28	19

Table 7-1.1.1 (continued)

Transformer KVA	Transformer Secondary Volts	Circuit Breaker Interrupting Rating Amperes Symmetrical	Minimum Length of Cable Between Transformer and Circuit Breaker† ft — MCM‡ 750	600	500	400	350	300	250	4/0	3/0	2/0	1/0	AWG‡ 1	2	4
	240	42,000	41	39	38	35	34	32	30	27	25	21	18	16	13	9
	600	42,000	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	480	50,000	4	4	4	4	4	4	4	3	3	3	3	3	2	2
	240	65,000	17	17	16	15	14	13	12	12	11	10	9	8	6	4
2,500	600	14,000	355	348	325	303	287	274	250	232	203	175	149	124	103	68
	480	22,000	165	157	151	142	135	129	118	109	97	83	72	60	50	33
	240	25,000	88	83	80	74	71	67	61	56	49	42	36	30	25	16
	600	22,000	180	173	167	158	151	143	131	123	109	95	82	68	57	39
	480	30,000	99	95	92	87	83	79	73	69	60	53	46	39	33	22
	240	42,000	44	42	41	38	37	34	32	30	27	23	19	16	13	9
	600	42,000	33	32	31	29	28	26	25	24	23	21	18	16	14	10
	480	50,000	27	26	25	24	23	22	21	19	18	16	15	13	11	8
	240	65,000	22	21	21	19	18	17	16	15	14	12	11	9	8	5

For SI Units: 1 ft = 0.3048 m.

Notes to Table 7-1.1.1

†Cable lengths are based on:

(a) Transformer impedance of 5.75 percent. If a higher impedance transformer is used, the cable length may be decreased for the same circuit breaker interrupting rating.

(b) Copper cables with three single conductors in a magnetic duct.

(c) 100 percent total connected motor load with motor contribution equal to four times transformer full load current.

‡Cable sizes listed are based on Temperature Rating of Conductors from 60°C to 90°C, as listed in NFPA 70, *National Electrical Code*, Table 310-16, and they provide proper cable sizing (125 percent motor full load current) for motors up to 125 horsepower at 240 volts, 250 horsepower at 480 volts, and 350 horsepower at 600 volts.

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 Enclosure. 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.

7-3.4 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 which 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 as defined in 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.

7-3.8 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.

7-3.9* Instructions. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller.

7-4 Components.

7-4.1 Isolating Means. The isolating means 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, as listed in NFPA 70, National Electrical Code, and also suitable for interrupting the motor locked rotor current, shall be permitted.

Exception No. 2: This isolating means is not required on limited service controllers.

7-4.1.1 The isolating means shall be externally operable (*see 7-3.6*).

7-4.1.2 The ampere rating of the isolating means shall be at least 115 percent of the nameplate current rating of the motor.

7-4.1.3 The following warning shall appear on or immediately adjacent to the isolating means:

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

7-4.1.4 The isolating means 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 means and the circuit breaker are so interlocked that the isolating means can neither be opened nor closed while the circuit breaker is closed, this latch is not required.

7-4.2 Circuit Breaker (Disconnecting Means).

7-4.2.1 The motor branch circuit shall be protected by a circuit breaker, as defined in Article 100 of NFPA 70, *National Electrical Code*, which shall be connected directly to the load side of the isolating means and shall have one pole for each ungrounded branch circuit conductor.

7-4.2.2 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 ⅜ in. (10 mm) high shall be located on the outside of the controller enclosure adjacent to the means for tripping the circuit breaker.

7-4.2.3* 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 interrupting rating equal to or greater than the available short circuit current for the circuit in which it is used.
5. The circuit breaker shall permit normal starting of the motor without tripping.

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.

7-4.3 Locked Rotor Overcurrent Protection. The only other overcurrent protective device which shall be required and permitted between the isolation means 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.

7-4.4 Motor Starter.

7-4.4.1 The motor starter shall be of the magnetic type with a contact in each ungrounded conductor.

7-4.4.2 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.

7-4.4.3 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.

7-4.4.4 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* Alarm and Signal Devices on Controller. A pilot lamp 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 lamp will indicate that the circuit breaker is closed and that power is available at the controller for starting. The lamp shall be accessible for replacement.

7-4.6 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.

(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.

7-4.7 Controller Alarm Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions covered in 7-4.6.

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. In the controller circuit there shall be provided a pressure-actuated switch having independent high and low calibrated adjustments. 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 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 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.

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 Manual Mechanical Control at Controller.

(a) The controller shall be equipped with a 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 1-minute running time for each 10 horsepower of motor rating (but which need not exceed 7 minutes) 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 7-4.4. 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 7-4.2, 7-4.3 and 7-5.3.2.

7-4.3

Exception No. 1: In addition to the overcurrent devices providing protection according to 7-4.2.7 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.

7-4.3-7(a)

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 7-4.2.7(a) is not required.

Exception No. 3: The fuses referred to in 7-4.2.9 shall be high voltage current limiting motor starting types.

7-7* Limited Service Controllers. Limited service controllers, complying with the provisions of this section, consisting of automatic controllers for across-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 7-4.2.3(2) and 7-4.3, the locked rotor overcurrent protection may be achieved by using (a) a direct heated thermal element circuit breaker having a standard rating at or next below 250 percent of the motor full-load current but not smaller than 150 percent or (b) an indirect heated thermal element circuit breaker having a standard rating at or next above 125 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 7-4.1 Exception No. 2 and 7-4.2.1.

7-7.1 Application. The following specifications cover automatic controllers for across-the-line-type squirrel-cage motors of 30 horsepower or less, 600 volts or less, where such use is acceptable to the authority having jurisdiction. Requirements in Sections 7-1 through 7-5 shall apply.

Exception No. 1: 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.

Exception No. 2: The manually operated isolating means specifed in 7-4.1 is not required.

7-7.2 Circuit Breaker. The circuit breaker shall comply with requirements in 7-4.2.

Exception No. 1: The calibration shall be of the fixed type to discourage adjusting and tampering by unauthorized persons.

Exception No. 2: The interrupting rating of the circuit breaker shall be not less than 10,000 amperes.

7-8 Transfer Switches for Emergency 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 and where on-site electrical switching equipment is used for power source selection, such equipment 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.

7-8.2 Definitions. Electrical switching equipment is defined by one of the following:

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.

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

7-8.3* Automatic Transfer Switch Features. (*See Figure A-7-8.3.*)

7-8.3.1 The automatic transfer switch shall be housed in a barriered compartment of the fire pump controller or in a separate enclosure and marked "Automatic Transfer Switch."

7-8.3.2 The complete assembly, consisting of fire pump controller and automatic transfer switch, shall be factory assembled as a single unit.

7-8.3.3 The complete assembly, as described in 7-8.3.2, shall be listed for fire pump service.

7-8.3.4 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 than 115 percent of the motor full-load current, and also suitable for switching the motor locked rotor current.

7-8.3.5 The automatic transfer switch shall be electrically operated, and mechanically held.

7-8.3.6 A means for safe manual (nonelectrical) operation of the automatic transfer switch shall be provided. This manual means need not be externally operable.

7-8.3.7 An isolating means, complying with 7-4.1, 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 means 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 means shall have a withstand rating not less than the available short-circuit current of the alternate source.

7-8.3.8 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 falls below the minimum operating voltage to allow the fire pump to deliver rated output, the transfer switch 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 load may be retransferred to the normal source.

7-8.3.9 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.

7-8.3.10 Two pilot lights, properly identified, or other approved position indicator shall be provided to externally indicate the transfer switch position.

7-8.3.11 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.

7-8.3.12 Means shall be provided to prevent higher than normal inrush currents when transferring the fire pump motor from one source to the other.

7-8.3.13 The transfer switch shall not have integral short-circuit or overcurrent protection.

7-8.3.14 Where the alternate source is provided by on-site power generation, the following shall be provided:

(a) A means 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 7-8.3.8.*)

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

7-8.3.15 The fire pump controller/transfer switch assembly (*see 7-8.3.2*) shall have a cautionary marking to indicate that the isolation means for both the controller and transfer switch is opened before servicing the controller, transfer switch, or motor.

7-8.3.16 A momentary test switch, externally operable, shall be provided on the transfer switch which will simulate a normal power source failure to the switch.

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

8-2.2 Engine Ratings.

8-2.2.1 Engines shall be rated at standard 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 1,000 sq 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 gear drives (*see 8-2.3.1*) are used between the pump and its driver, the horsepower requirement of the pump shall be increased to allow for power loss in the gear drive.

8-2.2.7 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.

8-2.3.2 Except for installations made prior to adoption of the 1974 edition of this standard, dual drive pump units shall not be used.

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

8-2.4.9 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.

8-2.5 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* Air Starting. When air starting is used and air pressure exceeds 100 psi (7 bars) gage, air supply tanks shall be so located or so guarded that they are not subject to mechanical injury. There shall be not less than two air supply containers, each sufficient for six consecutive 15-second cranking attempt starts without recharging. There shall be a separate, suitably powered air compressor or means of obtaining air from some other system, independent of any compressor driven by the fire pump engine. Suitable supervisory service shall be maintained to indicate high and low air pressure conditions.

8-2.6 Storage Battery.

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

Exception: This does not apply to installations made prior to adoption of this standard.

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). The fire pump manufacturer shall provide a certification that the battery furnished complies with this requirement.

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-9-4.2.3.*)

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.

8-2.7 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* By-pass. A by-pass 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 (3.8 L) per horsepower, 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 above ground in accordance with municipal or other ordinances and in accordance with requirements of the authority having jurisdiction, and shall not be buried. The vertical location of the fuel supply tanks shall be arranged so that the top level of 5 percent volume for sump shall be at the level of the fuel pump centerline transmitting fuel to the engine fuel supply pump, at the level of entrance to that pump. 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. A suitable, flexible metallic connection shall be provided in the fuel supply line where it connects to the engine fuel 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.

8-5 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.

Chapter 9 Engine Drive Controllers

9-1* General.

9-1.1 The requirements of this chapter cover manual/automatic controllers for diesel engine driving fire pumps.

9-1.2* All controllers shall be specifically listed for diesel engine driven fire pump service.

9-1.3 All controllers shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

9-1.4 All controllers shall be marked "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.

9-1.5 It shall be the responsibility of the pump manufacturer or a 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.

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.

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 Enclosure. 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.

9-3.4 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 leading from the panel to the engine and to the batteries shall have adequate carrying capacity. 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.

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

9-3.6 Wiring Diagrams and Instructions.

9-3.6.1 A wiring diagram shall be provided and permanently attached to the inside of the enclosure showing exact wiring for the controller, including identifying numbers of individual components. All wiring terminals shall be plainly and commonly marked and numbered to correspond with the wiring diagram furnished. For external engine connections, the terminal strips shall be commonly numbered.

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

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

9-4 Components.

9-4.1 Alarm and Signal Devices on Controller.

9-4.1.1* A pilot lamp(s) shall be provided to indicate that the controller is in the "automatic" position. The lamp shall be accessible for replacement.

9-4.1.2 Separate pilot lamps 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) Battery failure. Each battery shall be provided with separate lamps which shall be lighted or extinguished on battery failure.

9-4.1.3 No audible alarm silencing switch, other than the controller main switch, shall be permitted for the alarms in 9-4.1.2.

9-4.1.4 When audible alarms for the conditions listed in A-2-17 are incorporated with the engine alarms specified in 9-4.1.2 and 9-4.2.4, 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.

9-4.2 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:

9-4.2.1 Engine running (separate signal).

9-4.2.2 That controller main switch has been turned to "off" or "manual" position (separate signal).

9-4.2.3* Trouble on the controller or engine.

9-4.2.4 A common signal may be used for these trouble indications: items in 9-4.1.2 (a), (b), (c), (d) and (e) above, and loss of output of battery charger on the load side of the dc overcurrent protective device.

9-4.3 Controller Alarm Contacts for Remote Indication. Controllers shall be equipped with contacts (open or closed) to operate circuits for the conditions covered in 9-4.2.

9-4.4 Pressure Recorder. When a pressure recorder is used (*see A-9-5.2.7*), its chart drive shall be spring wound or ac electric with spring driven backup and shall operate for at least 7 days.

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.

9-5.2 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. 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) 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. The relay 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 controlling equipment shall be arranged to automatically start the engine at least once a week. A solenoid valve drain on the pressure control line shall be the initiating means.

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.

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 the trouble lamp and bell (audible alarm). 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 selector switch on the controller panel.

(b) Operation of a stop button 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.

9-5.4.2 Automatic Shutdown After Automatic Start.

(a) If the controller is set up for automatic engine shutdown (optional) after starting causes have been returned to normal, a running period time set for at least 30 minutes shall be used.

(b) When the emergency overspeed governor operates, the controller shall cause the engine to shut down without time delay, and lock out until manually reset.

9-5.5 Emergency Control. Automatic control circuits, the failure of which could prevent engine starting and running, shall be completely by-passed for manual control.

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 When gear drives or other power transmission devices are used between the pump and the turbine, the horsepower requirement of the turbine shall be increased to allow for power losses in these transmission devices.

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 drain automatically 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 adopted, 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.

11-1.1 Hydrostatic tests as required in 2-9.6 and 2-10.2, and flushing of the piping assembly shall be conducted in accordance with the requirements of the applicable NFPA standards for pressure and duration.

11-1.2 Hydrostatic tests shall be verified by completion of the contractor's certificate of material and test similar to Section 1-12 of NFPA 13.

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

11-2 Field Acceptance Tests.

11-2.1 The acceptance test of the pump installation shall be the responsibility of the installing contractor. The pump manufacturer or his representative shall be present for the 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. The test equipment shall be furnished by either the authority having jurisdiction, or the installing contractor or the pump manufacturer, depending upon the prevailing arrangements made between the abovementioned parties.

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 6-3.3.3.*)

11-2.6.3.3 Engine driven units shall not show signs of overload or stress. The governor of such units shall be set to properly regulate the minimum engine speed at rated pump speed at the maximum pump brake horsepower. (*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 perform not less than 10 automatic and 10 manual operations 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 An annual test of the fire pump assembly (pump, driver and controller) shall be performed to determine its ability to continue to attain satisfactory performance at peak loads. All alarms shall operate satisfactorily. All valves in suction line shall be checked to assure that they are fully open.

11-3.2 This annual test shall be performed by personnel trained in the operation of the fire pump.

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 Maintenance personnel shall be in attendance during the weekly pump operation for equipment so designed. The satisfactory performance of the pump, driver and controller shall be observed and noted.

11-4.5 When units are to be tested weekly by manual means, at least one start shall be accomplished by reducing the water pressure. This may be done with the test drain on the sensing line or with a flow from the fire protection system.

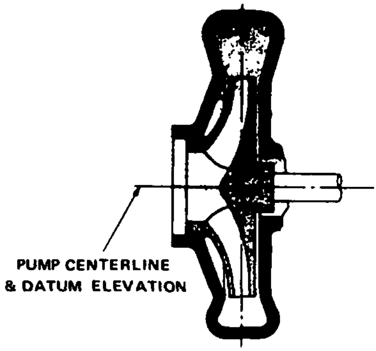
11-5 Fire Pump Maintenance.

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.

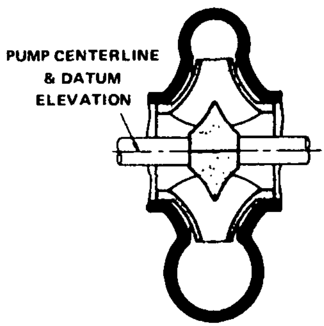
11-5.2 Replacement components are not restricted by the unit contract provisions of 1-5.1 and may be ordered as needed. Replacement components may be of a unique or special design and shall be purchased from the manufacturer's representative.

Appendix A

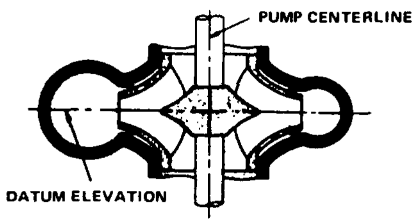
This Appendix is not a part of the requirements of this NFPA document...but is included for information purposes only.



END SUCTION PUMP



HORIZONTAL DOUBLE SUCTION PUMP



VERTICAL DOUBLE SUCTION PUMP

Figure A-1-7.5 Datum Elevation of Various Pump Designs.

A-1-7.5 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. The Datum Elevation is defined as follows: For horizontal units it is the centerline of the pump shaft (*see Figure A-1-7.5, "End Suction Pump and Horizontal Double Suction Pump"*). For vertical double suction pumps, it is the impeller discharge horizontal centerline (*see Figure A-1-7.5, "Vertical Double Suction Pump"*).

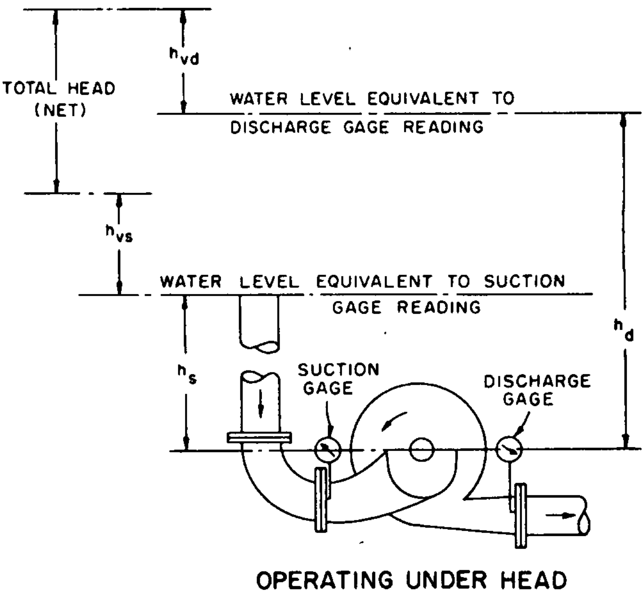


Figure A-1-7.5.7 Typical Head of Horizontal Shaft Centrifugal Fire Pumps.

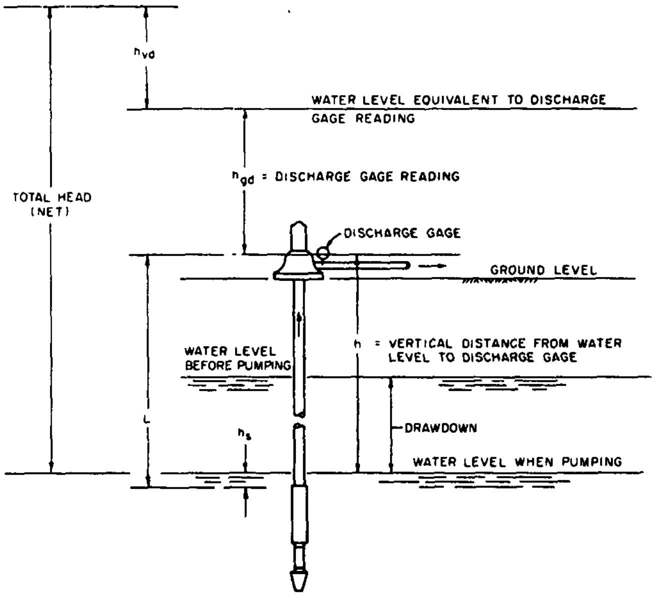


Figure A-1-7.5.8 Total Head of Vertical Turbine-type Fire Pumps.

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 for the Installation of Foam-Water Sprinkler Systems and Foam-Water Spray Systems*, Chapter 3.

(e) NFPA 24, *Standard for Outside Protection*, 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.

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-2-7 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.

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.

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).

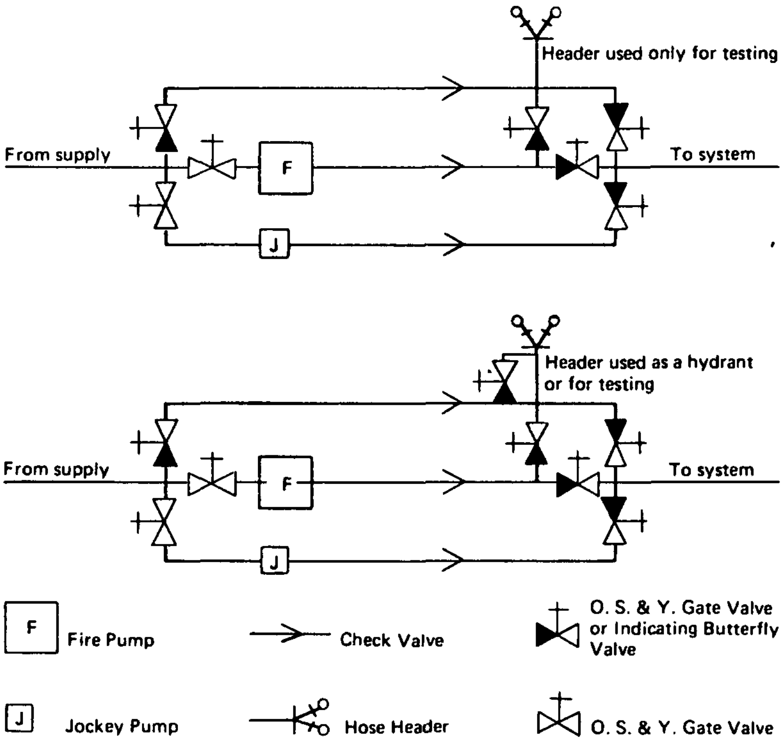


Figure A-2-9.5 Schematic Diagram of Suggested Arrangements for a Fire Pump with a By-Pass, Taking Suction from Public Mains.

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).

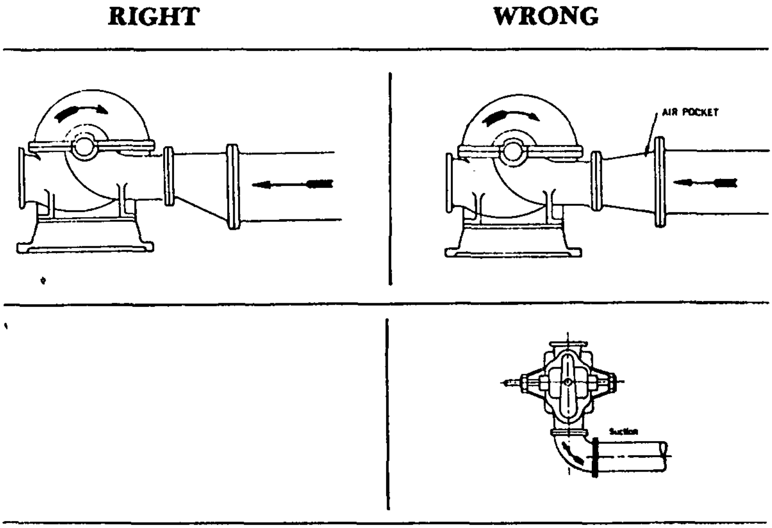


Figure A-2-9.6 Right and Wrong Pump Suctions.

See *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*, **Thirteenth Edition, for additional information.**

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-2-10.4 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-2-11 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 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-2-11.1 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-2-12.6 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 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-2-12.9 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-2-13.1.2 Outlets can be provided through the use of standard test headers, yard hydrants, wall hydrants or standpipe hose valves.

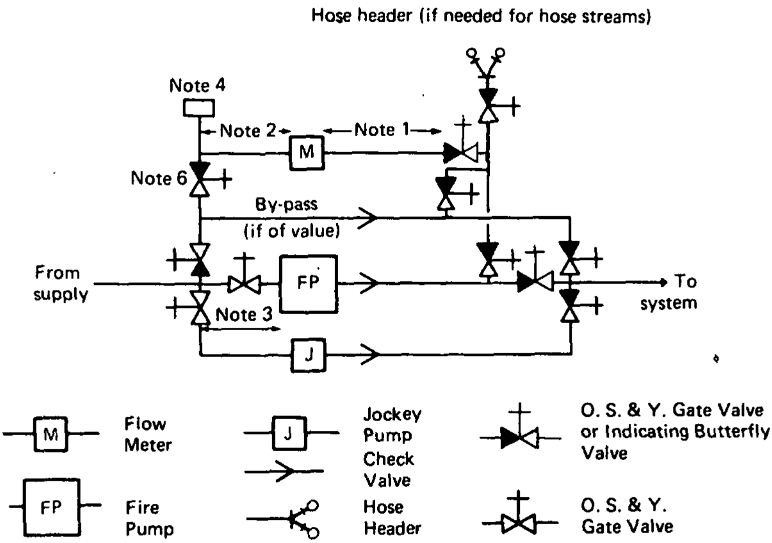


Figure A-2-13.2.1(a) Diagram of Preferred Arrangement for Measuring Fire Pump Water Flow with Meter for Multiple Pumps and Water Supplies, Water Discharge to Drain or to Pump Water Source.

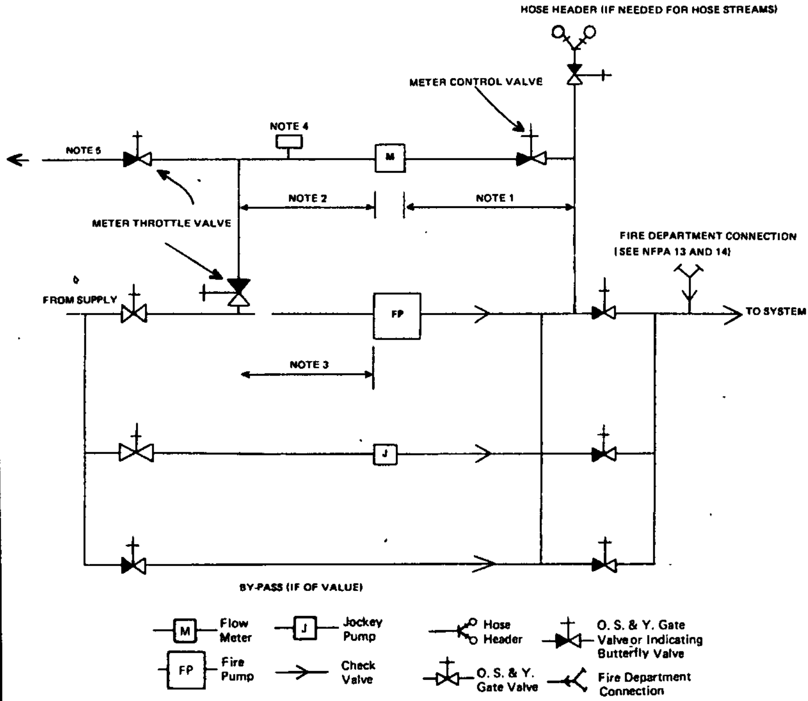


Figure A-2-13.2.1(b) Diagram of Typical Arrangement for Measuring Fire Pump Water Flow with Meter, Discharge to Pump Suction.

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.

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-2-13.2.1 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-2-13.3.1 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 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-2-16 (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 counter-clockwise (CCW).

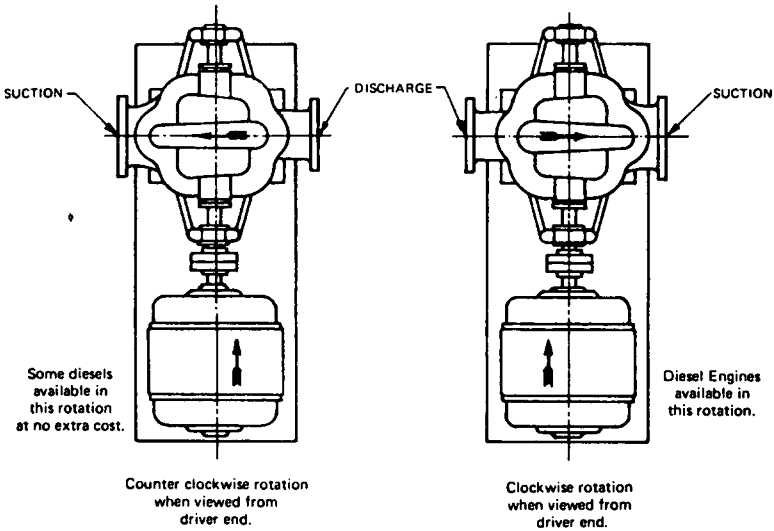


Figure A-2-16(b) Horizontal Pump Shaft Rotation.

A-2-17 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.

(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.

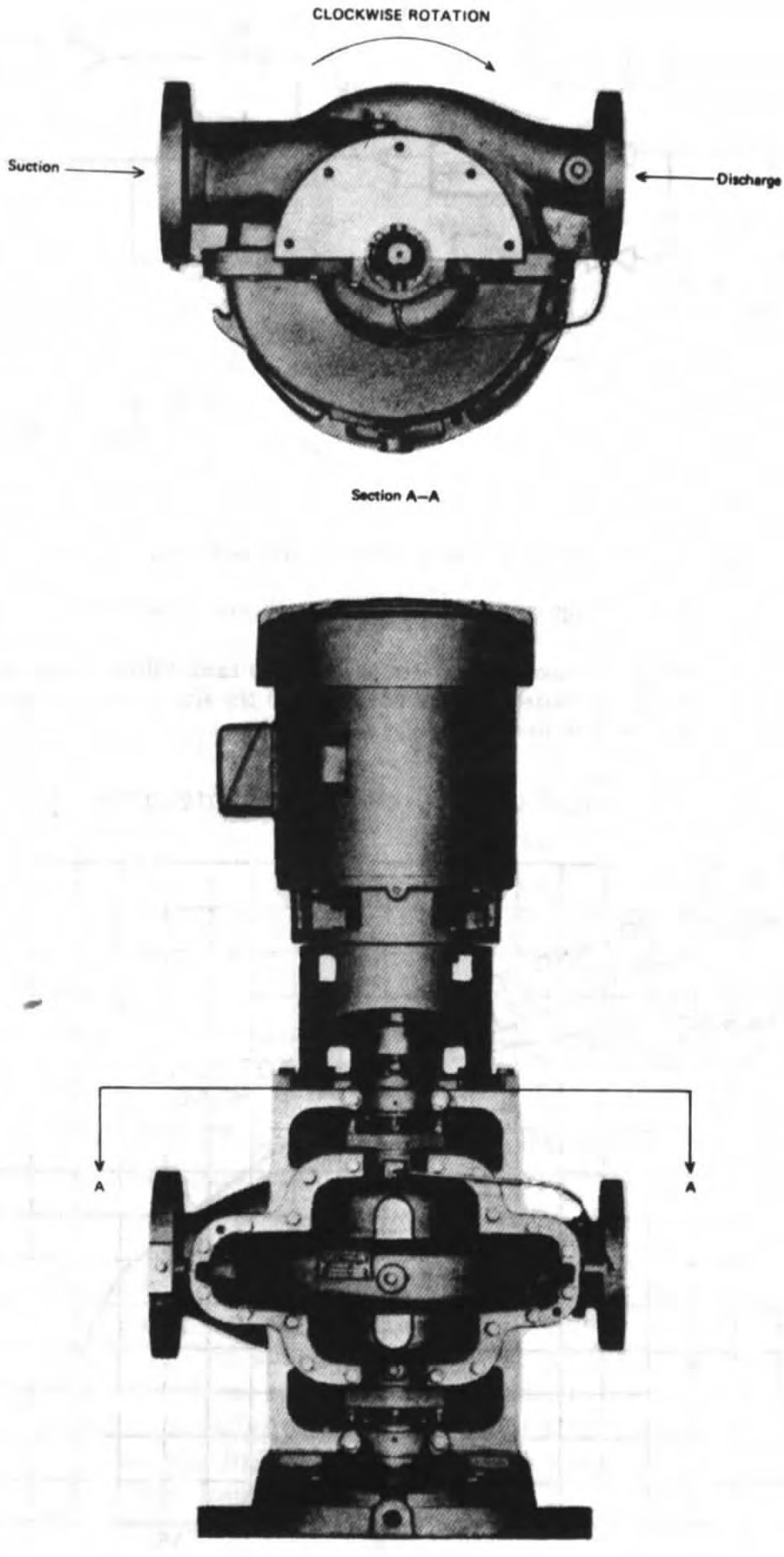


Figure A-2-16(c) Vertical Pump Shaft Rotation.

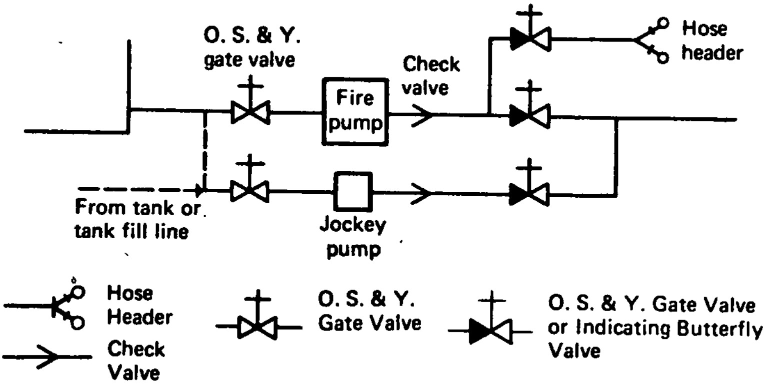


Figure A-2-19.3 Jockey Pump Installation with Fire Pump.

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.

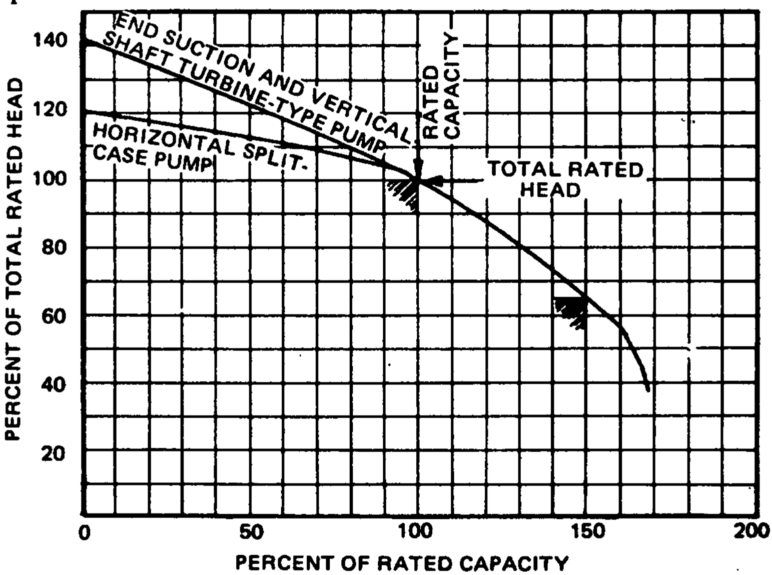


Figure A-3-2.1 Pump Characteristic Curves.

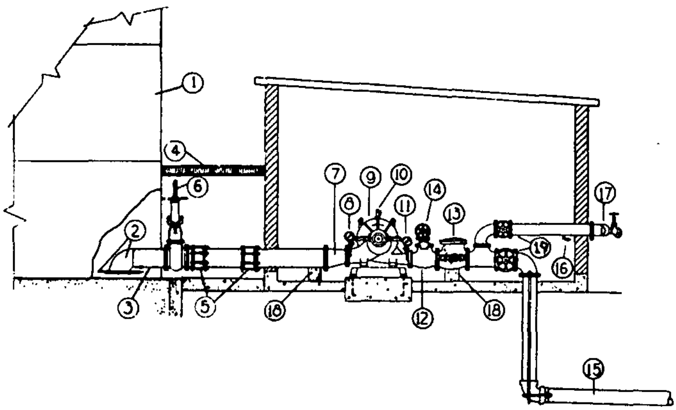


Figure A-3-3.1 Horizontal Split-Case Fire Pump Installation with Water Supply under a Positive Head.

1. Aboveground suction tank.
2. Entrance elbow and 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.

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 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.

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:

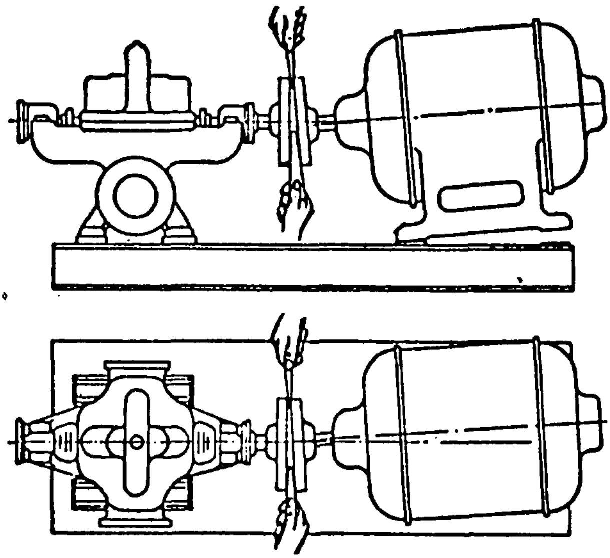
(a) Settling, seasoning or springing of the foundation. Pipe strains distorting or shifting the machine.

(b) Wear of the bearings.

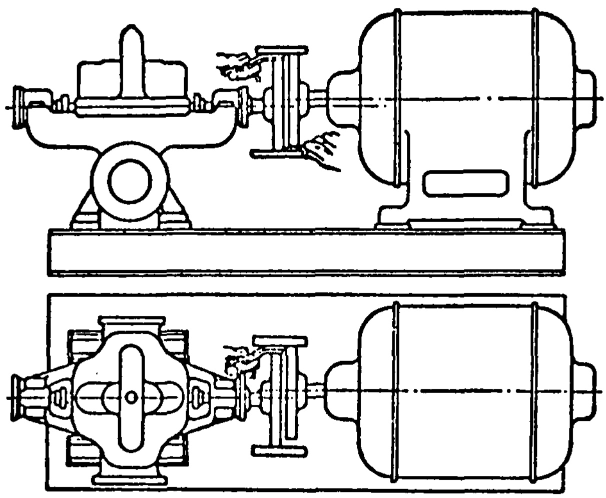
(c) Springing of the base plate by heat from an adjacent steam pipe or from a steam turbine.

(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.



Checking Angular Alignment[1]



Checking Parallel Alignment

Figure A-3-5

[1]Diagram reprinted from *Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps*. Copyright by the Hydraulic Institute, 1230 Keith Building, Cleveland, OH 44115.

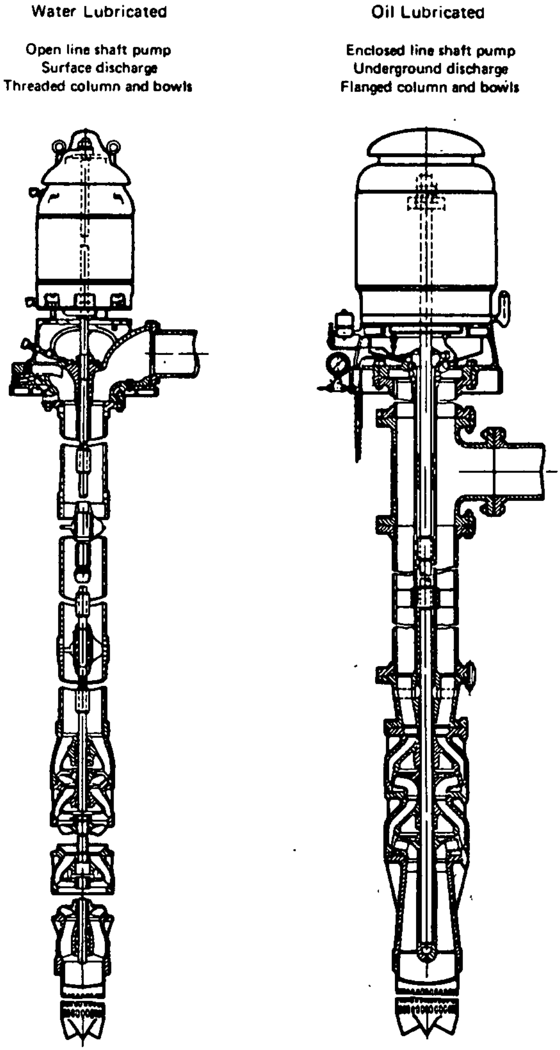


Figure A-4-1.1 Illustration of Water-Lubricated and Oil-Lubricated Shaft Pumps.

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.

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.

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.

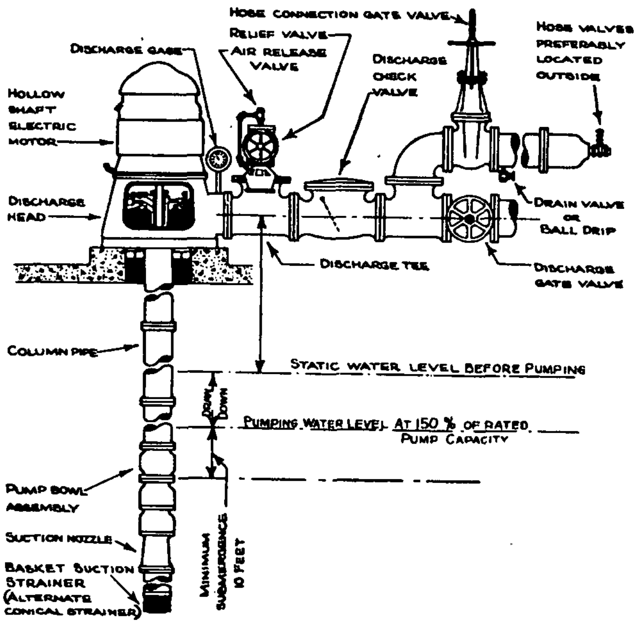


Figure A-4-2.2.1 Vertical Shaft Turbine-type Pump Installation in a Well.

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 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.

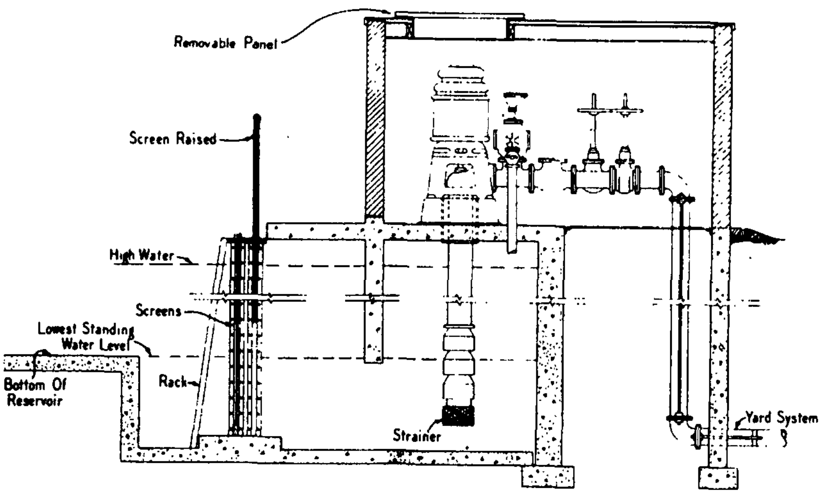


Figure A-4-2.2.2 Vertical Shaft Turbine-type Pump — Installation in a Wet Pit.

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-4-2.5 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.

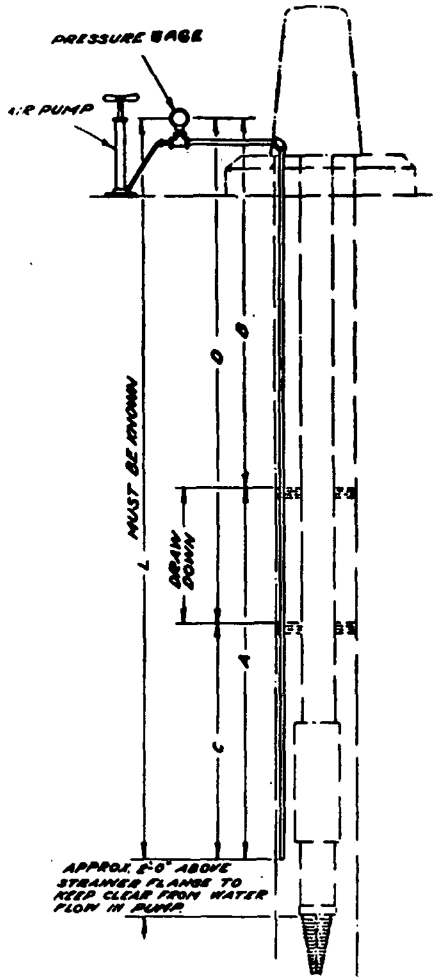
A-4-2.7 Test and Inspection of Well. Before the permanent pump is ordered, the water from the well should be analyzed for corrosiveness, including such items as pH, salts such as chlorides, harmful gases such as carbon dioxide (CO_2) or hydrogen sulfide (H_2S). If the water is corrosive, the pumps should 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.



For SI Units: 1 ft = 0.3048 m.

Figure A-4-3.5.3 Air Line Method of Determining Depth of Water Level.

Example: The following calculation will serve to clarify Figure A-4-3.5.3.

Assume a length (L) of 50 ft (15.2 m).

Pressure 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).

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.