NFPA No.

20

CENTRIFUGAL FIRE PUMPS 1970

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Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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Standard for the Installation of Centrifugal Fire Pumps.

NFPA No. 20 — 1970

1970 Edition of No. 20

This 1970 edition of the Standard for the Installation of Centrifugal Fire Pumps incorporates amendments prepared by the Committee on Fire Pumps and adopted by the National Fire Protection Association at the 1970 Annual Meeting. It supersedes the 1969 edition.

Revisions or additions in this edition are in: 514e, 624a, 624b, 714a3, 715f2, and 822a. 914b has been deleted.

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SCOPE: The selection and installation of pumps supplying water for private fire protection, including suction piping, valves and auxiliary equipment; operation and maintenance; electric driving and control; steam turbine and internal combustion engine driving and control equipment.

Origin and Development of No. 20

Since the formation of the committee in 1904 each edition of NFPA No. 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, 1911, 1912, 1913, 1915, 1918, 1919, 1920, 1921, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1931, 1932, 1933, 1937, 1939, 1943, 1944, 1946, 1947, 1948, 1951, 1953, 1955, 1957, 1959, 1960, 1961, 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, and 1970.

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STANDARD FOR THE INSTALLATION OF CENTRIFUGAL FIRE PUMPS.

NFPA No. 20 — 1970

General

1. Purpose. This standard contains, in general, the minimum requirements for centrifugal fire pumps, including horizontal, single and multi-stage pumps and vertical shaft turbine-type pumps; and is prepared to cover the design, installation and maintenance of such pumps together with their drivers, and for the guidance of the authority having jurisdiction and others concerned in judging the acceptability of such equipment.

2. Approval Prior to Purchase Recommended.

a. Centrifugal fire pumps should not be purchased until conditions under which they are to be installed and used have been examined by the authority having jurisdiction, and each pump, driver, controlling equipment, the power supply and arrangement, and water supply have been approved by that organization.

b. The pump manufacturer must be given complete information concerning the suction water supply as accepted by the authority having jurisdiction.

3. Unit Assembly Required.

a. The pump, driver and all necessary attachments shall be purchased under unit contracts stipulating compliance with this standard and satisfactory performance of the entire unit when installed.

b. The pump manufacturer shall be responsible for the proper operation of the complete unit assembly as indicated by field acceptance tests. (See Article 910 for field acceptance test procedure.)

4. Complete Plans and Data Required. A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted by the engineer or contractor to the authority having jurisdiction for approval before installation. Certified shop test characteristic curves showing head-delivery, efficiency and brake horsepower shall be furnished by the manufacturer.

PART I — PUMP ARRANGEMENT, TEST AND INSTALLATION.

Chapter 1 — Basic Information

10. General.

11. APPROVED PUMPS REQUIRED. Centrifugal fire pumps shall be specifically approved for fire pump service.

20. Water Supplies.

21. REQUIREMENTS. Fire pumps should be provided with as large and reliable a supply of water as possible. The adequacy and the dependability of the source of water are of primary importance and must be fully determined at the time of installation, also the prospects for its reliability in the future. The minimum water level with maximum discharge from the pump must be determined. Where a stored supply is the only one available, a reliable method of replenishing the supply should be provided. Representatives of the pump manufacturer shall assist in establishing these facts to the satisfaction of the authority having jurisdiction. Water supplies containing salt or other materials deleterious to the fire protection systems should be avoided wherever possible.

30. Pump.

31. RATED CAPACITIES OF PUMPS.

a. STANDARD PUMPS — Standard fire pumps are those having rated capacities of 500, 750, 1,000, 1,500, 2,000 and 2,500 gpm. Larger pumps may be used in specially engineered applications.

b. SPECIAL PUMPS — Special fire service pumps are those having rated capacities of 200, 300 and 450 gpm.

32. TYPES OF PUMPS.

a. STANDARD FIRE PUMPS — Pumps rated at capacities within the standard capacity range and pressures of 100 psi or more.

b. LOW-PRESSURE FIRE PUMPS (BOOSTER PUMPS) — Pumps rated at capacities within the standard capacity range and pressures between 40 and 100 psi.

c. SPECIAL FIRE SERVICE PUMPS — Pumps rated at 200, 300 or 450 gpm limited to 130 per cent capacity maximum, and for various pressures. The maximum power re-

quired shall not exceed the limitations of a 30-horsepower electric motor.

d. PRESSURE MAINTENANCE PUMPS (JOCKEY OR MAKE-UP PUMPS) — The use of an automatic pressure maintenance pump is desirable under some circumstances to maintain a uniform or a relatively high pressure on the fire protection system. The capacity and pressure rating of the pump shall be sufficient to maintain the desired pressure against the leakage in the system as approved by the authority having jurisdiction. A centrifugal type pump is preferable. Where the discharge pressure at pump shut-off of a centrifugal type pump exceeds the working pressure rating of the fire protection equipment, or a turbine vane (peripheral) or a positive displacement type of pump is used, a suitable relief valve shall be installed on the pump discharge to prevent damage to the fire system. (See Figures 100a-1 and 143e.)

33. STANDARDS ON CAPACITY AND PRESSURE. For requirements on capacity and pressure refer to Standard for the Installation of Sprinkler Systems (NFPA No. 13) and Standard for the Installation of Standpipe and Hose Systems (NFPA No. 14) and for hydrants, Standard for Outside Protection (NFPA No. 24).

34. NAME AND CAPACITY PLATE. Pumps shall be provided with a Name and Capacity Plate.

40. Installation.

41. THE PUMP ROOM.

a. The fire pump shall be protected against possible interruption of service through damage caused by fire or water, in a manner satisfactory to the authority having jurisdiction.

b. Except where there are several pumps on the same system, located in buildings which are not all subject to one fire, or where the pump is automatically controlled and supplies automatic sprinklers only, the pump should be in a room so located and constructed as to protect it from falling floors or machinery and from fire which might drive away the operator or damage the pump or driving equipment.

NOTE: Where the use of brick or reinforced concrete is not feasible, metal lath and cement plaster is recommended for the construction of the pump room.

c. The pump room should be of ample size, and the piping and equipment should be so arranged as to make them readily accessible for operation or repair. The pump room should not be used for storage purposes.

NOTE: With vertical type pumps it may be necessary to provide a removable panel in the pump house roof to permit the pump to be lifted out for repairs.

d. The location of the pump room should be such as to permit installation of short and direct pipe connections, the suction pipe receiving first consideration.

e. Suitable means shall be provided for maintaining the temperature of the pump room above 40°F.

f. Artificial light shall be provided, and provision made for drainage and ventilation of the pump room. A suitable lamp or lantern should be provided for emergency use. Emergency lighting may be provided from the battery circuit of an internal combustion engine.

g. Pump rooms housing electric or engine driven pumps should be dry and free from condensate. Some heat may be required to accomplish this.

42. DISCHARGE PIPE.

a. The size of discharge pipe shall be as given in the following table unless otherwise specified by the authority having jurisdiction.

Capacity of Pump, gpm	500	750-1000	1500-2000	2500
Size of Discharge Pipe, inches	6	8	10	12

b. An approved check valve shall be installed in the discharge pipe.

c. Approved indicating gate valves shall be installed in such places as needed to make the pump and check valve accessible for repair.

NOTE: This requires a valve on the system side of the check valve and on the supply side of the pump if the supply may at any time be under a head.

43. RELIEF VALVE.

a. Pumps connected to adjustable-speed drivers shall be equipped with an approved relief valve. Where pumps are driven by constant-speed motors and the shut-off pressure plus the static suction pressure exceeds the pressure

for which the system is designed to operate, relief valves are required.

b. The relief valve should ordinarily be set to prevent pressure on the fire protection system in excess of that pressure at which the system was designed to operate.

c. Where provided, relief valves shall be of the size given in the following table:

Capacity of Pump, gpm	500	750	1000	1500	2000-2500
Size of Relief Valve, inches	3	4	4	6	6

d. The relief valves should be located between the pump and the pump discharge check valve.

e. The relief valve should discharge into an open pipe in plain sight near the pump or into a cone or funnel secured to the outlet of the valve. This cone should be so constructed that the pump operator can easily see any water wasting through the relief valve, and it should be so made as to avoid splashing water into the pump room. If a closed type cone is used, it should be provided with means for detecting motion of water through the cone. The cone should be piped to a point where water can be freely wasted, preferably outside the building.

f. If the relief valve waste 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. Discharge from the relief valves should not be piped into the suction connection, except with the permission of the authority having jurisdiction.

g. When the supply of water is taken from a suction reservoir of limited capacity, the waste pipe shall drain into such reservoir, entering as far from the pump suction as is necessary to prevent the pump from drafting air which may be carried down by the discharge from the waste pipe.

h. The relief valve waste pipe from an open cone should not be smaller than specified below; if more than one elbow is employed the next size larger pipe should be used to complete the connection.

Capacity of Pump, gpm	500	750	1000-1500	2000-2500
Size of Waste Pipe, inches	5	6	8	10

i. The relief valve waste pipe from a closed cone shall be sized to prevent back pressure in excess of 8 psi.

j. The relief valve shall be so attached as to permit of its ready removal for repairs without disturbing the waste piping.

44. HOSE VALVES.

a. Approved 2½-inch hose valves of the number specified in Paragraph 44b shall be provided for use in testing the pumps. The hose valves should ordinarily be attached to a header or manifold; they shall be connected by suitable piping to the pump discharge piping, preferably at a point between the discharge check valve and the discharge gate valve. The hose valves should be so located as to avoid any possible water damage to the driving motor or engine or their controllers, and should preferably be outside the pump room. Where located outside, or at a distance from the pump, and there is any danger of freezing, an approved indicating gate valve and drain valve shall be located in the line to the hose valves at a point close to the pump.

b. Unless otherwise specified by the authority having jurisdiction, the number of hose valves shall be as given in the following table, except that for special service fire pumps and for booster pumps, only one hose valve is required for five hundred gallon or smaller pumps.

Capacity of Pump, gpm	500	750	1000	1500-2000	2500
Number of Hose Valves	2	3	4	6	8

c. On the larger capacity fire pump installations, there should be installed a fixed nozzle or pipe outlet arranged to discharge at an appropriate place, or a metering device in a pipe line discharging back into the suction supply, for use in making a flow test to the full capacity of the pump or pumps. With such test arrangements the authority having jurisdiction may permit a reduction in the number of hose valves to the number needed for hose stream use.

d. Hose valves shall be threaded to conform to the American (National) Standard B26-1925 for Fire Hose Coupling Screw Threads. Adapter couplings securely attached to each outlet shall be provided if local couplings are not American Standard.

e. When 2 hose valves are required, use 4-inch pipe between the detachable hose header and the connection to

the discharge pipe; when 3 or 4 are required use 6-inch pipe; when 6 or 8 are required use 8-inch pipe. When this pipe is over 15 feet long increase one pipe size.

45. PRESSURE GAGES.

a. A pressure gage having a dial not less than 3½ in. in diameter shall be connected near the discharge casting by a ¼-in. cock with lever handle. The dial shall indicate pressure to at least twice the rated working pressure of the pump but not less than 200 psi. The face of the dial shall read in pounds per square inch with the manufacturer's standard graduations.

b. A compound pressure and vacuum gage having a dial not less than 3½ in. in diameter shall be connected to the suction pipe near the pump (except in the case of vertical shaft turbine type pumps). The face of the dial shall read in pounds per square inch for the suction range and have a maximum pressure range not less than twice the rated working pressure of the pump, or a lower pressure range may be furnished if the gage is protected from damage by a gage protector.

46. CIRCULATION RELIEF VALVE TO PREVENT OVERHEATING. Pumps which are automatically controlled shall be provided with a ¾-inch relief valve set slightly below the shut-off pressure and arranged to permit circulation of sufficient water to prevent the pump from overheating when operating with no discharge. This is not needed for submerged type pumps nor for engine driven pumps for which engine cooling water is taken from the pump discharge. Pumps which are manually controlled shall be equipped with either such a relief valve or with a test valve as specified in Section 133. Provision should be made for discharge to a drain.

47. SUMMARY OF PUMP DATA

Capacity of Pump gpm	Size of Discharge Pipe See 42(a)	Size of Relief Valve See 43(c)	Size of Relief Waste See 43(h)	Number Hose Valves See 44(b)
500	6 in.	3 in.	5 in.	2
750	8 in.	4 in.	6 in.	3
1000	8 in.	4 in.	8 in.	4
1500	10 in.	6 in.	8 in.	6
2000	10 in.	6 in.	10 in.	6
2500	12 in.	6 in.	10 in.	8

50. Power Supply.

51. DEPENDABILITY OF POWER SUPPLY. Careful consideration must be given in each case to the dependability of the power supply not overlooking the possible effect on transmission lines of fire in the property or in adjoining buildings which might threaten the property.

60. Tests.

61. SHOP TESTS.

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

b. The maker shall test each pump hydrostatically before shipment from the factory, to twice the maximum pressure developed at shutoff, but in no case less than 250 pounds per square inch. Pump casings shall be substantially tight at the test pressure. In the case of vertical shaft turbine type pumps both the discharge casting and pump bowl assembly shall be tested.

c. All gear drives shall be operated at the factory under full load before shipment and operate without excessive noise or heating during the test.

Chapter 100 — Horizontal Shaft Pumps

110. General.

111. APPLICATION. The horizontal shaft centrifugal pump with its split casing lends itself to simple operation and repair, and, where a water supply is obtainable under a head, it is especially adaptable to fire service. Because the horizontal shaft centrifugal pump requires priming when installed to operate under lift, a vertical shaft turbine type pump should be used where suction lift is necessary.

112. PERFORMANCE.

a. Pumps shall furnish not less than 150 per cent of rated capacity at a total head not less than 65 per cent of total rated head. The shut-off total head for horizontal shaft pumps should not exceed 120 per cent of total rated head (Fig. 1, Appendix C).

b. The inlet pressure available from a suction water supply shall be figured on a basis of a flow of 150 per cent of the rated capacity of the pump, as indicated by a flow test.

120. Water Supplies.

121. OPERATE UNDER HEAD. Fire pumps, especially those automatically controlled, should be provided with water under head, avoiding suction lifts whenever possible. Operating suction lifts, including allowance for velocity and friction loss through all suction fittings, shall not exceed 15 feet at sea level and the allowable lift must be reduced by 1 foot for each 1000 feet of altitude at the pump installation. Where a suction lift is necessary, a vertical shaft turbine type pump should be used. (See Paragraph 111.)

122. PRIMING SUPPLIES.

a. Provide adequate priming supplies for pumps which may at any time take suction under a lift. Priming equipment should have sufficient capacity to displace the air from the pump and suction pipe within three minutes.

b. Provide two reliable methods of priming the pump. One of these methods of priming should be independent of public water connections or tanks serving as primary supplies for automatic sprinklers, yard hydrants or standpipes.

c. Where the pump is automatically started or provision is made for remote manual starting, the preferred arrangement is a submerged pump (see Fig. 200a, Appendix C), but if priming is needed the priming supply should be of a type which will keep the pump primed at all times. No priming method should be selected which will permit contamination of a potable water supply.

123. PRIMING METHOD A. *An Automatically Filled Priming Tank.*

a. An automatically filled priming tank that keeps the pump primed at all times. The volume of the priming tank should be equal to the volume of the pump and suction pipe but not less than 100 gals. This volume can be readily computed from the following data.

CAPACITY OF PUMP Gpm	PRIMING WATER REQUIRED FOR PUMP AND FITTINGS, Gallons	SIZE OF SUCTION PIPE, Inches	PRIMING WATER REQUIRED FOR SUCTION PIPE, Gallons per foot
500	13	6	1.5
750	21	8	2.5
1000	25	10	4.1
1500	38	12	5.9
2000	47	14	8.0
2500	58	16	10.5
		20	16.3

b. The water supply to the tank should be capable of keeping the tank full at all times.

c. The priming tank should be connected to the discharge side of the pump at a point which will insure that all priming water enters the pump and suction pipe, and is not wasted in the discharge pipe of the pump (Fig. 100b, Appendix C). This connection should be 2 inches in diameter irrespective of the capacity of pump, and include an approved O. S. & Y. gate valve and an approved check valve.

124. PRIMING METHOD B. *A Connection to a Domestic Water System.* A connection to a domestic water system (when permitted by health regulations). Install approved check and O. S. & Y. gate valves in the priming pipe near the pump.

125. PRIMING METHOD C. *A Connection to a Domestic-use Tank.* A connection to domestic-use (service) tank

(when permitted by health regulations). Preferably arrange a reserve supply for priming only, by extending service riser up into the tank. Install approved check and O. S. & Y. gate valves in the priming pipe near the pump.

126. PRIMING METHOD D. *An Exhauster or Siphon Ejector.* Where a reliable steam supply or separate water supply under good pressure is available, an exhauster or siphon ejector may be connected between the pump and discharge check valve to exhaust the air from the pump and the suction pipe (Fig. 100b, Appendix C). An approved O. S. & Y. gate valve should be placed in the exhauster connection, to be closed as soon as the pump is primed.

127. PRIMING METHOD E. *A Mechanically-Operated Exhauster Driven by a Separate Motor.* The exhauster should be connected between pump and discharge check valve, so as to completely fill suction pipe and pump (Fig. 100b, Appendix C). An approved O. S. & Y. gate valve should be placed in the exhauster connection, to be closed as soon as pump is primed.

128. PRIMING METHOD F. *A Manually Filled Priming Tank.*

a. The tank to have a capacity of at least three times the volume of the pump and suction pipe, but not less than 250 gallons. A liberal-sized priming tank and large connecting pipe are necessary so that the pump can be primed quickly, even if there should be considerable leakage at the foot valve. As the priming arrangement is so vital a feature to the successful starting of the pump, a considerable safety factor is needed.

b. The volume required for the priming tank can be readily computed by taking 3 times the quantities given under Section 123.

c. The tank should be connected to the pump as covered in Section 123 with the connecting pipe not smaller than given in the following table:

Capacity of Pump, gal. per min.	500	750	1000	1500-2500
Size of Priming Pipe, inches	2½	3	3½	4

d. Where suction pipe is longer than 25 feet, larger priming connection may be required.

e. Provide a means for keeping tank filled such as a connection from public or factory-use water systems or a connection between fire pump and the priming tank to permit refilling tank.

129. PRIMING METHOD G. *A By-Pass Around Discharge Check Valve.* Where a good gravity water supply constitutes the primary supply for automatic sprinklers, yard hydrants or standpipes, a 2-inch by-pass around the check valve in the pump discharge pipe may be used but only as a secondary priming supply.

130. Pump.

131. OUTLINE OF REQUIRED ATTACHMENTS.

a. This standard requires horizontal fire pumps to be equipped with the following attachments, depending on the conditions under which the pumps are to be installed:

Automatic air release, Section 132.
Circulation relief valve, Section 46.
Eccentric tapered reducer at suction inlet, Paragraph 143i.
Hose valve manifold with hose valves, Section 44.
Pressure gages, Section 45.
Priming connection, Sections 122 to 129.
Relief valve and discharge cone, Section 43.
Splash shield between pump and motor, Section 455.
Test valve with piping connections, Section 133.

b. These attachments shall be provided by the pump manufacturer unless the authority having jurisdiction permits certain omissions depending on the conditions under which the pumps are to be installed.

132. AUTOMATIC AIR RELEASE. Pumps which are automatically controlled shall be provided with a reliable float-operated air release valve not less than ½ inch in size, or equivalent valve, to automatically release air from the pump.

133. TEST VALVES.

a. Pumps taking suction under lift shall be equipped with test valves of the size specified below, in order to provide means for liberating the air from the pump

and suction line within the three-minute time limit for the priming operation.

Capacity of Pump, gpm	500	750	1000	1500-2500
Size of Valve, inches	1¼	1½	2	2½

b. Test valves shall be piped so that water wasted through them can be seen by a man at the pump.

NOTE: Unless the pump attendant can see the discharge of water, there is danger that he will allow water to be wasted which might be seriously needed for fire fighting.

140. Installation.

141. FOUNDATION AND SETTING.

a. Unless the pump and driver have a common shaft, they shall be connected by an approved flexible coupling arranged to permit end adjustment and to care for minor inaccuracies in alignment.

b. The pump and driver shall be securely attached to a solid foundation in such a way that proper shaft alignment will be assured: such as by having the pump and driver rigidly connected to a substantial bedplate which is securely bolted to the foundation.

c. The foundation should preferably be made of concrete, or, if desired, of brick laid in portland cement mortar.

NOTE: Where the foundation is of brick a capping of concrete is an advantage in tying it together. In some cases it may be necessary to support the pump on I-beams or a framework of structural steel.

d. Pumps shall be set level, with foundation bolts in position, and the joint between the foundation and bedplate made solid by grouting with neat cement. After the cement has thoroughly set the bolts shall be tightened. For further information see Instructions for Installing Centrifugal Pumps in Centrifugal Pump Section of the Standards of the Hydraulic Institute.

142. ALIGNMENT.

a. A horizontal pump with driver is correctly aligned on bedplate before shipment. This alignment, however, usually is disturbed during transit or by incorrect leveling of bedplate on foundation. The pump manufacturer's instructions on alignment should be carefully followed.

b. Any base plate, no matter how heavily it is built, may be slightly sprung in shipment, or may be distorted by an uneven support on the foundation, or by uneven tightening of the foundation bolts, or by the pull from the pipe connections. It is necessary to be careful when installing the pump to secure perfect alignment of the coupling. A *flexible coupling will not compensate for misalignment.* Inaccurate alignment of the coupling results in rapid wear of the coupling bushings, heating of the bearings and loss of efficiency. Therefore, after the pump is fastened on the foundation it is necessary to see that the shaft of the pump and of the prime mover are in one line. If the prime mover and pump are direct connected remove the coupling bolts, if not already removed. The pump should be completely connected up to its piping and the base plate then leveled up and adjusted to position so as to bring the two halves of the coupling into perfect alignment.

c. With a pair of inside calipers or a wedge, check the distance between the coupling halves at four points and repeat after revolving both halves 180 degrees.

d. Both suction and discharge pipes should be independently supported near the pump so that when the flange bolts are tightened no strain will be transmitted to the pump casing.

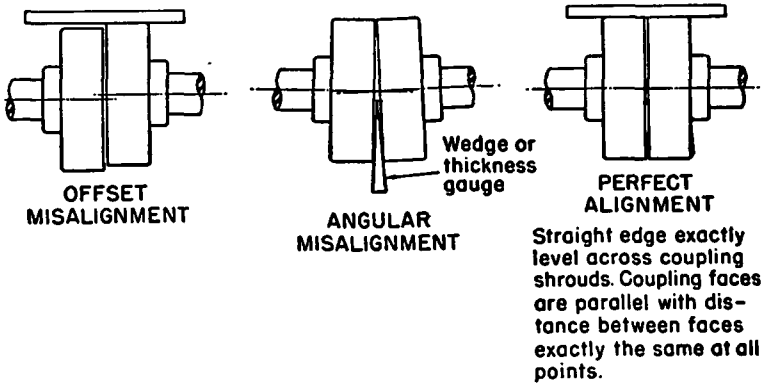

Fig. 142. Proper and Improper Shaft Alignment.

143. SUCTION CONNECTIONS.

a. The size of suction pipe should be determined from Fig. 143a (Appendix C). These curves include an allowance for velocity and friction loss through elbows and foot valves.

b. Suction pipe should be of the same pressure rating as the yard piping and installed in accordance with the Standard for Outside Protection, NFPA No. 24. For short pipe. well-supported, flanged cast iron pipe with rubber gaskets should be used. In special cases steel pipe having flanged or screwed joints (flanged joints with flanges welded to the pipe are preferred) may be used above ground in the pump room provided it is galvanized or painted on the inside, prior to installation, with a paint recommended for submerged surfaces. Thick bituminous coatings applied at the plant should not be used. The exterior of steel pipe should be kept painted. Cement asbestos pipe may be used when the pump takes suction under a head at all times.

c. Avoid an excessive length of suction pipe to a pump room under lift by providing a suction well close to the pump. The well can be fed by gravity through a large pipe from the suction source.

d. Provide independent suction pipes where more than one pump is supplied under lift from the same intake or suction well. In special cases where a single suction pipe supplies more than one pump under head, the piping layout at the pumps must be symmetrical so that each pump will receive its proportional supply. The size of the suction pipe should be such that with all pumps operating at overload capacity the total operating suction lift will not exceed 15 feet.

e. When the suction supply is under sufficient pressure to be of material value without the pump, the pump should be installed with a by-pass (Fig. 143e, Appendix C).

f. Suction pipes involving a lift must be carefully laid to avoid air leaks and air pockets, either of which may seriously affect the operation of the pump. Lay a suction pipe involving a lift so that it will have a constantly ascending grade from the water supply to the pump (Fig. 143f, Appendix C).

g. Lay suction pipe below the frost line. Pay special attention where pipe enters streams, ponds, or reservoirs to prevent freezing either underground or under water (Fig. 100b, Appendix C). Avoid horizontal elbows near the pump (Fig. 143f, Appendix C).

h. All pump suction pipe, except short lengths between above-ground suction tanks and pumps, should be hydrostatically tested in accordance with the tests for yard mains given in the Standard for Outside Protection (NFPA No. 24) before back filling.

i. When the suction pipe and pump suction connection are not of the same size, connect them with an eccentric tapered reducer in such a way as to avoid air pockets (Fig. 143f, Appendix C).

j. Equip suction pipes which may at any time involve a lift with approved foot valves except when two completely independent exhaust-type priming methods are provided. Piping should be arranged to permit removing foot valves for inspection and cleaning. Combination foot valves and strainers should not be used.

k. Provide an approved O.S. & Y. or approved indicator type gate valve in the suction pipe if the pump is ever supplied under a head.

NOTE 1: If suction pressure comes from city or service water mains, the gate valve should normally be located at the suction flange on the pump. (item 6A in Figure 100 a)
NOTE 2: If suction pressure comes from a stored water container, the gate valve should normally be located at the outlet of the container. (item 6 in Figure 100 a)

l. Suction inlets should be at least 24 inches below minimum water level to prevent pumps from drafting air, and at least 12 inches above the bottom of sump or suction well to avoid obstruction (Fig. 100b and Fig. 143l, Appendix C).

m. Provide double removable intake screens (Fig. 100b, Appendix C) having an effective net area of openings below minimum water level of one square inch for each gallon per minute of 150 per cent of rated pump capacity

at suction intakes where it is necessary to prevent the passage of materials which might clog the pump. Screens should be so arranged that they can be cleaned or repaired without disturbing the suction pipe. A brass or copper wire screen of one-half inch mesh and No. 10 B. & S. gage wire. secured to a metal frame sliding vertically at the entrance to the intake, makes a serviceable arrangement, and permits ready cleaning and overhauling. The over-all area of this particular screen is 1.6 times the net screen opening area. In some localities, suction supply for fire pumps from public water mains may require the installation of an approved strainer to prevent foreign material from passing through the pump into the system piping.

n. When pump and suction supply are on separate foundations with rigid interconnecting piping, the piping should be provided with strain relief. (See Figure 100 a, item 5.)

Chapter 200 — Vertical Shaft Turbine-Type Pumps.

210. General.

211. SUITABILITY. The deep well turbine-type pump is particularly suitable for fire pump service when the source of water is located below the surface of the ground and it would be difficult to install any other type of pump below the minimum water level. It is a vertical shaft centrifugal pump with rotating impellers suspended from the pump head by a column or eduction pipe which also serves as a support for the shaft and bearings. It was originally designed for installation in bored wells, but may also be used to lift water from lakes, streams, open sumps, and other sub-surface sources. Oil-lubricated enclosed line shaft or water-lubricated open line shaft pumps will be acceptable.

212. MAXIMUM DEPTH. Wells should not be considered as a source of supply for fire pump service where the water level when pumping at 150 per cent capacity exceeds 200 feet from the surface of the ground. In all applications where the water level is expected to exceed 50 feet the authority having jurisdiction shall be supplied with data on the draw-down characteristics of the well and the pump performance to determine the available discharge pressure at the discharge flange of the vertical pump.

213. ACCEPTABLE DRIVE. These pumps may be operated by vertical shaft electric motor or, when equipped with a suitable right angle gear drive, they may be operated by an internal combustion engine or a steam turbine. Careful consideration must be given in each case to the dependability of the source of power.

214. 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 direction of a representative of the pump manufacturer.

215. PERFORMANCE. Pumps shall furnish not less than 150 per cent of rated capacity at a total head of not less than 65 per cent of the total rated head. The shut-off total head shall not exceed 140 per cent of total rated head (Fig. 1, Appendix C).

220. Water Supply.

221. SOURCE.

a. The water supply shall be acceptable to the authority having jurisdiction. Stored water supplies from reservoirs or tanks supplying wet pits are preferable. Lakes, streams and ground water supply may be acceptable where investigation shows that they can be expected to provide a suitable and reliable supply.

b. The acceptance of a well as a source of water supply shall be dependent upon satisfactory development of the well and the making of a preliminary test to determine hydraulic conditions. 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.

222. PUMP SUBMERGENCE.

a. Proper submergence of the pump must be provided for reliability of operation of the fire pump unit.

b. WET PIT INSTALLATIONS. The minimum submergence should be such that the second impeller from the bot-

tom of the pump bowl assembly will be below the lowest standing water level in the open body of water supplying the pit (Fig. 200b, Appendix C). The minimum submergence shall be increased by one foot for each 1000 feet of elevation above sea level.

c. WELL INSTALLATIONS. Submergence of the second impeller from the bottom of the pump bowl assembly should be 10 feet below the pumping water level at 150 per cent of rated capacity. (See Figure 200 a, Appendix C.)

223. WELL CONSTRUCTION.

a. It shall be the ground water supply contractor's responsibility to make one or more test holes, if necessary, in search of water-bearing formation, develop a well to meet the required water production necessary for a specific pump, to perform all work and install all equipment in a thorough and workmanlike manner.

b. Each well completed must be of ample diameter and depth and sufficiently straight to receive the pump. The turbine-type pump is designed to operate in a vertical position with all parts in correct alignment; it cannot operate in a crooked well unless the turbine unit hangs freely without being cramped.

224. UNCONSOLIDATED FORMATIONS.

a. All casings shall be 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 conform to the thickness and weight in Table 224.

TABLE 224

Nominal Size (ID) Inches	Wall Thickness Inches	Weight per Foot (Plain Ends) Pounds
8	0.277	24.70
10	0.307	34.24
12	0.330	43.77
16 and larger	0.375	—

b. Outer casing shall extend down to approximately the top of the water-bearing formation. The inner casing of lesser diameter and well screen shall extend into the water-bearing formation as the water-bearing stratum encountered may justify and, in the contractor's opinion, best meet the conditions.

c. It should be emphasized that the well screen is a vital part of the well construction and careful attention should be given to its selection. It shall be the same nominal diameter as the inner casing and of the proper length to provide for the quantity of water to be developed. The screen shall be made of stainless steel material (304) except that Monel metal shall be used where it is anticipated that the chloride content of the well water will exceed 1000 parts per million. The screen shall have adequate strength to resist the external forces that will be applied after it is installed and to minimize the likelihood of damage during the installation.

d. The bottom of the well should be sealed properly with a cement plug or a plate of the same material as the screen. The sides of the outer casing should be sealed by the introduction of neat cement placed under pressure from the bottom to the top.

e. The immediate area surrounding the well screen should be properly prepared with clean and well-rounded gravel of such size and quantity as will create a gravel filter to insure a low velocity and friction loss of water leaving the water-bearing formation and entering the well.

225. CONSOLIDATED FORMATIONS. Where wells take their supply from consolidated formations, such as rock, the specifications should be decided upon by the authority having jurisdiction upon consultation with a recognized ground water consultant in the area. In instances where the drilling penetrates unconsolidated formations above the rock, surface casing shall be installed, seated in solid rock and cemented in place.

226. DEVELOPING A WELL. Developing a new well and cleaning it of sand (not to exceed five parts per million) shall be the ground water supply contractor's responsibility and should be done with a test pump and not the new fire pump which could be ruined before it is placed in service. Freedom from sand shall be determined when the test pump is operating at 150 per cent of rated capacity of the fire pump for which the well is being prepared.

227. TEST AND INSPECTION OF WELL.

a. A test to determine the water production of the well shall be made with an acceptable type of water measuring device such as an orifice, a venturi meter or a calibrated pitot tube, and shall be witnessed by a representative of the

customer, contractor and authority having jurisdiction, as required. The test shall be continuous for a period of at least eight hours at 150 per cent of the rated capacity of the fire pump, with averaged hourly readings over the test period. The tests should be evaluated in the light of 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 per cent of the rated capacity of the fire pump for which the well is being prepared.

b. The well work completed by the ground water supply contractor should be carefully examined and if there is some doubt about straightness of well, gaging and plotting is recommended before acceptance of the well.

c. Before the permanent pump is ordered, the water in 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-resisting material such as bronze or red brass in accordance with chemical analysis and experience in the area.

230. Pump.

231. DISCHARGE HEAD. The discharge head should be of the aboveground type (Fig. 200a and b, Appendix C). In every case the discharge head shall be designed to support the driver, the pump column and the oil tube tension nut or packing container. The discharge head shall also act as a water passage to direct the water from the column into the discharge fittings.

232. PUMP COLUMN.

a. The column shall be furnished in sections not exceeding a nominal length of 10 feet, shall be of minimum weight conforming to specifications in Table 232, and shall be connected by threaded sleeve type or flange type couplings. 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 pump column. All column flange faces shall be parallel and machined for rabbet fit to permit accurate alignment.

TABLE 232.

Nominal Size (ID), Inches	Outside Diameter, Inches	Weight per Foot (Plain Ends), Pounds	Nominal Size (ID), Inches	Outside Diameter, Inches	Weight per Foot (Plain Ends), Pounds
6	6.625	18.97	10	10.750	31.20
7	7.625	22.26	12	12.750	43.77
8	8.625	24.70	14*	14.000	54.57
9	9.625	28.33			

*OD

b. Open line shaft water-lubricated columns shall not be used where the distance from the pump head to the static water level exceeds 50 feet.

c. If the pump is to be of the enclosed line shaft oil lubricated type the shaft enclosing tube shall be furnished in interchangeable sections not over 10 feet 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.

233. BOWL ASSEMBLY.

a. The pump bowl shall be of close-grained cast iron or bronze, and provided with bronze wearing rings or other suitable material in accordance with the chemical analysis of the water and experience in the area, as per Paragraph 224b.

b. Impellers shall be of bronze of the enclosed or semi-open type.

234. SUCTION STRAINER.

a. A cast or heavy fabricated type of non-ferrous 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 of such size to restrict the passage of a ½ inch sphere.

b. This suction strainer shall be required in addition to intake screen, specified under Paragraph 143m.

235. FITTINGS.

a. The following fittings to be furnished by the pump manufacturer shall be required for attachment to the pump. (Some shown in Fig. 200a, Appendix C).

Discharge tee or elbow.
Hose valve head (separable type), Section 44.
Hose valves, Section 44.
Automatic air release valve and fittings, Paragraph 235b.
Discharge gage conforming to Section 45.
Relief valve and discharge cone, when required by Section 43.
Water level testing device, Paragraph 235 c.

b. A 1½-inch or larger automatic air release valve is required to vent air from the column and discharge head upon starting the pump and also to serve to admit air to the column to dissipate the vacuum when the pump is stopped. This valve shall be located at the highest point in the discharge line between the fire pump and the discharge check valve.

c. Each pump installed in a well must be equipped with a suitable water level detector. The air line method (Section 236) is considered as a satisfactory method of determining depth of water level. This device should be permanently installed.

236. 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 by Fig. 236. 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 Fig. 236 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 and the other is fitted with an ordinary bicycle valve to which a bicycle pump is attached. All joints must be made carefully and must be air tight to obtain correct information. When air is forced into the line by means of the bicycle pump the gage pressure increases until all 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 feet (psi pressure × 2.31 = feet) from the known length of the air line will give the amount of submergence.

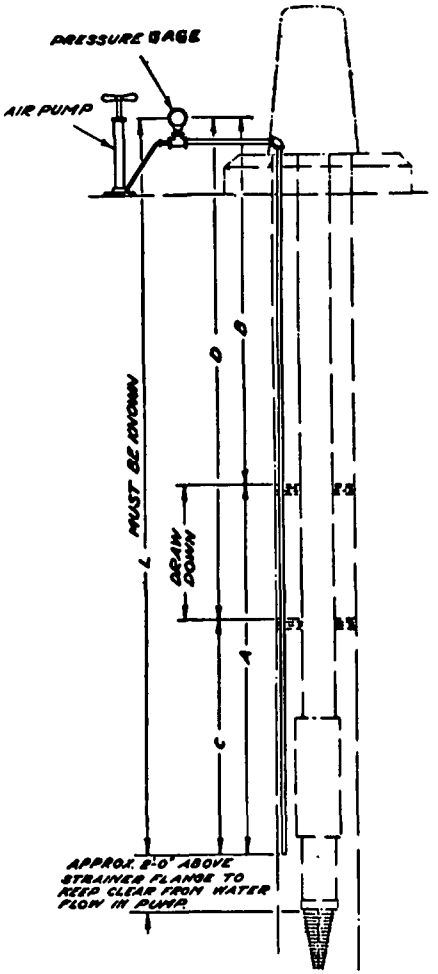

Fig. 236. Air Line Method of Determining Depth of Water Level.

EXAMPLES: The following examples with Fig. 236 will serve to clarify the above explanation.

Assume a length (L) of 50 feet.

Pressure gage reading before starting fire pump (p_1) = 10 psi. Then "A" = 10 × 2.31 = 23.1 feet, therefore the water level in the well before starting the pump would be B = L − A = 50 − 23.1 = 26.9 feet.

Pressure gage reading when pumping = (p_2) = 8 psi. Then C = 8 × 2.31 = 18.5 feet, therefore the water level in the well when pumping would be D = L − C = 50 − 18.5 feet = 31.5 feet.

The drawdown may be determined by any of the following methods:

(a) D − B = 31.5 − 26.9 = 4.6 feet.
(b) A − C = 23.1 − 18.5 = 4.6 feet.
(c) $p_1 - p_2 = 10 - 8 = 2$ psi.
$= 2 \times 2.31 = 4.6$ feet.

240. Installation.

241. PUMP HOUSE. The pump house should be of such character as will offer the minimum obstruction to the convenient handling and hoisting of vertical pump parts. Otherwise the requirements of Section 41 and Section 666 should apply.

242. OUTDOOR SETTING. If in special cases the authority having jurisdiction does not require a pump room and the unit motor is installed outdoors the motor shall be screened, and adequately protected against tampering. The screen should be easily removable and provision made for ample ventilation. A sheet metal on iron frame is better than wood.

243. FOUNDATION.

a. The pump foundation for vertical type pumps should be substantially built to carry the weight of the entire pump full of water and the driver. It should be rigid enough to withstand and prevent any vibration. Area of the base of foundation should extend at least 3 inches beyond the pump head base plate on all sides and be of sufficient area and strength so that the load per square foot on concrete does not exceed the ordinary foundation standards, or two I-beams of sufficient length and weight may be used on either side of well.

b. Certified prints can be obtained from the pump manufacturer giving the necessary dimensions.

c. Top of the foundation shall be carefully leveled to permit the pump to hang free in the well.

d. Where pump is mounted on I-beam over a pit the right angle gear housing and driver should always be installed parallel to beams, *never at right angle.*

244. METHOD OF ERECTING.

a. Several methods of installing a vertical pump may be followed, depending upon the location of the well and facilities available. Since most of the pump unit is underground, extreme care must be used in assembling and installing it and thoroughly checking the work as it progresses. The installation should be made under supervision of a representative of the pump manufacturer.

b. 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 suction 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.

NOTE: A series of drawings illustrating this procedure will be found in Appendix C. See Figures 244b-1, 2, 3 and 4.

245. SETTING IMPELLERS. The setting of the impellers should only be undertaken 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; full capacity is vital for fire pump service. The top shaft nut should be locked or pinned after proper setting.

250. Driver.

251. METHOD OF DRIVE.

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

b. Motors shall be direct connected, of the vertical, hollow shaft type, drip proof, normal starting torque, low starting current, squirrel cage induction type. The motor shall be equipped with an antireverse ratchet.

c. Gear drives must be acceptable to the authority having jurisdiction. Gear drives shall be of the hollow shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment. The gear drive shall be equipped with an antireverse rachet.

d. Where internal combustion engines under manual control are used, it shall be the pump manufacturer's responsibility to furnish a coupling of suitable design which will prevent undue strain on either the engine or pump by reverse operation. Automatic starters are equipped with an antidieseling device which serves to prevent reverse operation from self ignition during compression.

e. If dual drive is used, all equipment shall be of approved type and shall include approved free-wheeling clutches (see Paragraph 623.b).

252. CONTROLS. The controls for the motor, steam turbine or internal combustion engine shall comply with the sections of this standard which cover these controls.

260. Tests.

261. FIELD ACCEPTANCE AND SUBSEQUENT TESTS.

a. When the installation is completed, with wells and pumping equipment all in place, and necessary adjustments

and connections made, an operating test shall be made in the presence of the customer, pump manufacturer and representative of the authority having jurisdiction. Requirements regarding field acceptance tests in Article 910 should be followed insofar as they apply, excepting that for well installations the test shall include a continuous run long enough to satisfy the authority having jurisdiction that the permanent pump performs as required, but in no event shall the test be for less than one hour.

b. A yearly inspection and test at 150 per cent rated capacity to determine water level and condition of pump should be made.

270. Operation and Maintenance.

271. OPERATION.

a. In starting the unit for the first time after installation it is advisable to check over all electrical connections to the motor and also the discharge piping from the pump. Then momentarily operate the motor to see that the pump shaft rotates in a counter-clockwise direction when viewed from above.

b. With these precautions taken the pump may be started and allowed to run. Observe the operation for vibration while running and also any heating of the motor.

272. VIBRATION.

a. Pumping units are checked at the factory for smoothness of running and performance and should operate satisfactorily on the job. If excessive vibration is present several conditions may cause the trouble — a bent pump or column shaft, impellers not properly set within the pump bowls, pump not hanging freely in the well, or strain transmitted through the discharge piping.

b. If vibration develops later the unit should not be continued in operation. The pump manufacturer should be requested to service the installation and to place it in proper running condition.

273. EXCESSIVE MOTOR TEMPERATURE. This condition is generally caused either by a maintained low voltage of the electric service, or when the impellers are not properly set within the pump bowls.

274. REPAIR.

a. Manufacturer's instructions must be carefully followed in making repairs, taking apart and reassembling the pumps. This work should only be undertaken by someone familiar with their design.

b. In ordering spare or replacement parts use the pump serial number stamped on the name plate fastened to the pump head.

Chapter 300 — Special Fire Service Pumps.

310. General.

311. APPLICATION. Special fire service pumps are intended for installation in situations where the available supply of water is limited and draft of water in excess of the maximum delivery of the pump would be likely to reduce the supply pressure to an undue extent. It is not usually advisable to reduce the pressure in public mains below 20 pounds per square inch suction pressure while the pump is operating at its rated capacity. Special fire service pumps may also be used as booster pumps in situations where there is no deficiency in the volume of water available but the pressure is inadequate to supply the quantity of water necessary for efficient discharge from the highest sprinklers. The authority having jurisdiction may permit the use of these pumps for other special situations where such use is acceptable to said authority. They are for use only where the conditions are not such as to justify installation of a standard fire pump.

312. USE. Special fire service pumps may be installed instead of standard fire pumps only when their installation is approved by the authority having jurisdiction.

320. Water Supplies.

321. CAPACITY. Installation of pumps shall conform to the applicable provisions of Article 20 and Section 121.

330. Pump.

331. STANDARD PUMPS. Standard special fire service pumps have nominal capacities of 200, 300 and 450 gallons per minute with pressure ratings between 40 and 100 psi. The pumps shall have such performance characteristics that the power required of the driving motor will not exceed 30 horsepower at any rate of water delivery within the delivery range shown by the head-delivery curve of the pump.

332. SELECTION OF PUMP. Selection of a pump for a given condition should be based on the capacity and pressure conditions in the supply mains as determined by test, and the capacity and pressure requirements of the installa-

tion. The pump chosen should be one which has a capacity and pressure rating not less than required without exceeding the capacity limit of the supply main. Where a characteristic curve is not available it should be assumed that the pump may have a maximum suction demand of 130 per cent of its rated capacity.

333. PUMP REQUIREMENTS. The pumps shall be specifically approved for fire service. They should be of the horizontally-split case type. They shall have such performance characteristics that, at zero lift, the maximum capacity will not exceed 130 per cent of the rated capacity.

340. Installation.

341. GENERAL. Installation of pumps shall conform to the applicable provisions of Articles 40 and 140. See particularly Paragraphs 41a, e, and f, and 141a and b.

342. ATTACHMENTS.

a. Two pressure gages conforming to Section 45 shall be provided, one attached on the discharge and one on the suction side of the pump.

b. A discharge fitting with valved outlet for attachment of 2½-inch hose shall be provided for testing purposes.

c. Means shall be provided for automatic release of air from the pump and for circulation of sufficient water to prevent the pump from overheating. An air release valve not less than ½ inch in size, and a ¾ inch pressure relief valve set slightly below the shut-off pressure, are recommended. (See Section 46.)

350. Driver.

351. CAPACITY. Motors shall be of such capacity that at rated voltage (and on a.c. motors at rated frequency) their full load ampere rating will not be exceeded (except as allowed by the service factor stamped on the name plate) under any conditions of pump load. It shall be the pump manufacturer's responsibility to provide a motor of ample size to drive the pump, taking into consideration the suction pressure.

352. INSTALLATION. Motors and their power supply shall conform to the applicable provisions of Chapter 400. See particularly Articles 410, 420 and 430 and Sections 451, 454, 456 and 457.

360. Tests.

361. SHOP TEST. The pump shall be tested in the shop with a dynamometer or calibrated motor, and performance curves showing the head, capacity, efficiency and brake horsepower of the pump shall be furnished to the purchaser promptly after the test, and, upon request, to the authority having jurisdiction.

370. Contracts.

371. PURCHASE CONTRACT. It is recommended that the pump, motor and controller be purchased under a unit contract.

PART II — DRIVE AND DRIVE CONTROLLERS FOR PUMP.

Chapter 400 — Electric Drive

410. General.

411. ELECTRICAL EQUIPMENT. Electrical equipment shall comply with the National Electrical Code (NFPA No. 70), except as modified or provided herein.

NOTE: See Par. 2421 of the NFPA Standard for Installation of Sprinkler Systems (NFPA No. 13) regarding supervision of centrifugal fire pumps constituting the sole sprinkler supply.

420. Power Station.

421. SINGLE POWER STATION. When current is taken from a single power station, the station should be of noncombustible construction, so located or protected as to be free from chances of serious damage by exposure from fire, and the design and arrangement of apparatus within it such that there will be but little chance of interruption of service.

422. FROM A SUB-STATION. Where current is taken through a sub-station this sub-station should also meet the requirement of Section 421 and in addition the number and arrangement of cables between the station and the sub-station should be such as to practically guarantee continuous power at the sub-station.

423. OTHER SOURCES.

a. Where service cannot be obtained from a power station or sub-station meeting these requirements, it should be obtained from two or more stations or sub-stations so located and equipped that an accident or fire at one will not cause an interruption of the service supplied by the others.

b. A private generating plant located on the premises served by the fire pump, if in a separate power house or cut off from main buildings, will be considered as a power station, and may be used as one source of current supply.

430. Power Supply Lines.

(See Fig. 430, Appendix C, for illustrative Diagrams.)

431. Type of Lines.

a. The lines between the power plants and the pump room should be of such number, so arranged and so located that there will be small chance of an interruption of service to the motor, due to accident to the lines.

b. All wiring in the pump room shall be in approved rigid metal conduit, electrical metallic tubing or liquid-tight flexible metal conduit, or for 600 volts or less may be approved mineral insulated metal sheathed cable (type MI).

Note: Where the monetary values involved are large and the crippling of this pump service would seriously affect the protection of the property, at least two separate lines from the power plant or plants to the pump installation should be provided. The lines should be run by separate routes or in such a manner that a failure of both at the same time will be only a remote possibility.

Where current is taken from an underground Edison 3-wire system it will be considered that two independent lines have been provided if connections are brought into the pump room from two street mains or feeders not terminating directly in the same junction box.

A complete underground circuit from generating station to pump is strongly recommended and should be obtained when practicable. When such construction is not available, an overhead circuit may be allowed, but that part of the circuit adjacent to the plant or exposing plants should be run with special reference to damage in case of fire. Where the pump room is a part of, or in close proximity to, the plant which the pump is designed to protect, the wires for some distance from the pump room should be underground.

432. Capacity of Lines.

a. Each line between the power plant and pump room shall be of such size that its carrying capacity, as given by the National Electrical Code (NFPA No. 70), will not be exceeded.

b. The voltage at the motors should not drop more than 5 per cent below the voltage rating of the motors when the pumps are being driven at rated output, pressure, and speed, and the lines between motors and power stations are carrying their peak loads.

c. Where squirrel-cage motors are used, the capacity of the generating station, the connecting lines and the transformers should be ample and such as not to cause the voltage

to drop sufficiently to prevent the motor starting (not more than 10 per cent below normal voltage).

d. When 208-220 (or 208-220/440) volt motors are used on 208 volt nominal lines, the 5 per cent voltage drop allowed in 432b shall be figured from the 220 volt rating.

433. POWER SUPPLY PROTECTIVE DEVICES (Fuses or circuit breakers).

a. Such devices when installed in the power supply circuits at utility plants, substations, or plant load distribution centers ahead of the fire pump feeder circuits shall hold indefinitely stalled rotor current conditions of the fire pump motor(s) under maximum plant load.

b. Such devices (fuses not recommended) when installed in the fire pump feeder circuit shall hold indefinitely stalled rotor current of the fire pump motor(s) and other necessary associated fire pump installation electrical accessories.

NOTE: Each ungrounded conductor should be protected. See also 514b.

440. Transformers.

441. INSTALLATION. Transformers shall be installed in accordance with the requirements of the National Electrical Code (NFPA No. 70). If in the transformer room, there should be access from the outside of the building.

442. ISOLATION. Transformers supplying current to the lights and motors in the building served by the fire pump may also supply the pump motor, provided all load except the pump motor load can be quickly cut off when necessary. Switches for doing this must be in the pump room unless transformer room is near pump room, in which case they may be in transformer room.

443. LOCATION. Room containing transformers installed solely to supply current to a pump motor must be dry and heated in cold weather, or else the transformers must be normally left connected to the supply lines.

450. Motors.

451. TYPES — 600 VOLTS OR LESS. Electric motors are an accepted dependable source of power for operation of centrifugal fire pumps. All fire pump motors shall be rated for continuous duty and shall not be used at voltages in

excess of 110 per cent of rated voltage. It is the pump manufacturer's responsibility to provide a motor of ample size as specified in Section 453. Only motors wound for 200 or 208 volts shall be used for 208 volt services when the voltage may be less than that determined in accordance with 432d. Direct- or alternating-current motors may be used in accordance with the following requirements:

a. Direct-current motors shall be either of the stabilized shunt type, or cumulative compound-wound type. The speed of the motor at no load hot shall not exceed the speed at full load hot by more than 10 per cent.

b. Alternating current motors may be of the squirrel-cage induction type with across-the-line type starting equipment unless their starting characteristics would be objectionable to the company furnishing the power, in which case primary resistance primary reactor or auto-transformer type starting may be employed, or a wound rotor type of motor with appropriate starting equipment may be substituted.

c. Squirrel-cage induction motors should 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 following values:

		Motor Designation (NEC Code Letter)	
Rated Horsepower	*Locked Rotor Current Three-Phase 220 or 230 Volts (See Note 1)*	*220 Volts A to and Including*	*230 Volts A to and Including*
		(See Note 2)	
5	92	H	J
7½	127	H	H
10	162	G	H
15	232	G	G
20	290	F	G
25	365	F	G
30	435	F	G
40	580	F	G
50	725	F	G
60	870	F	G
75	1085	F	G
100	1450	F	G
125	1815	F	G
150	2170	F	G
200	2900	F	G

NOTE 1: In the foregoing table the locked rotor currents are for motors rated at 220 or 230 volts. They 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 following factors:

Rated Voltage	*Factor*
208 Volts	1.1
440 or 460 Volts	0.5
550 or 575 Volts	0.4
Any other Voltage	Ratio of 230 volts to the rated voltage.

(For example: a 15 H.P., 460 Volt motor would have a value of 116 amperes).

NOTE 2: Code letters of motors rated for 440 or 550 volts shall conform with those shown for 220 Volts. Code letters of motors rated for 208 Volts, 460 Volts, 575 Volts and all other Voltages shall conform with those shown for 230 Volts.

452. TYPES — IN EXCESS OF 600 VOLTS. All fire pump motors shall be rated for continuous duty and shall not be used at voltages in excess of 110 per cent of rated voltage. Voltages above 600 are not recommended for fire pump service, but where it is impracticable to use low voltage, higher voltages may be accepted by the authority having jurisdiction, for motor ratings of approximately 75 horsepower and larger at 2,300 volts and for motor ratings of approximately 100 horsepower and larger at 4,000 volts.

453. CURRENT LIMITS.

a. All motors shall be of such capacity that at rated voltage (and on a.c. motors at rated frequency) their full load ampere rating will not be exceeded (except as allowed by the service factor stamped on the name plate) under any conditions of pump load.

b. Motors used at altitudes above 3300 feet shall be operated or derated according to NEMA Standard MG1-14.14 (1963).

454. MARKING.

a. Marking of motor terminals shall be in accordance with the current American Standard C6 for Rotation, Connections and Terminal Markings for Electric Power Apparatus.

b. A name plate shall be provided showing the following information:

DIRECT-CURRENT MOTORS —

Manufacturer's type and frame designation.

Rated horsepower output.

Time rating.
Voltage.
Temperature rise or class of insulation.
Ambient temperature.
RPM at full load.
Full load amperes.
Shunt or compound wound.

ALTERNATING-CURRENT MOTORS —

Squirrel-cage Motors —

Manufacturer's type and frame designation.
Rated horsepower output.
Time rating.
Rpm at full load.
Frequency.
Number of phases.
Voltage.
Full load amperes.
Code letter.
Service factor, if other than 1.0.
Temperature rise or class of insulation and ambient temperature.

Wound Rotor Induction Motor —

In addition to information required in previous paragraph, also show secondary amperes at full load and secondary voltage.

455. WATER PROTECTION.

a. Open motors which are subject to possible splash of water from hose connections close to the pump, shall be protected against such splashing by some means such as a noncombustible, moisture-resisting partition, furnished by the pump manufacturer, installed between the pump and the motor.

b. Drip-proof motors shall be arranged as described above unless the hose valves are located outside the pump room.

c. Splash-proof motors shall be acceptable without splash partition as described above, providing the ventilating inlet and discharge are located so as to prevent impact of dripping or splashing water on windings or other energized mechanisms.

d. Motors of totally enclosed, fan cooled type shall be acceptable without splash partition. They shall be sealed at the joints and have conduit fittings arranged to prevent the entrance of water.

NOTE: See item 19 in Appendix A-Glossary for a description of the various types of electric motors.

456. OTHER FEATURES.

a. Motor shall be equipped with anti-friction ball or roller-type bearings mounted so as to be effectively sealed against dirt and moisture.

b. Instructions as to lubrication and care of motor bearings shall accompany each motor.

c. The terminal box shall be of a type which can be arranged for attaching conduit at sides, top or bottom. A totally-enclosed fan-cooled motor shall be provided with a watertight conduit box.

d. Where unusual moisture or abrasive dust conditions are anticipated, motors shall be of special type or specially insulated to withstand such conditions. Under such conditions high voltage motors shall be totally enclosed.

457. CONFORMANCE. Motors furnished for centrifugal fire pump use shall be guaranteed to conform with these specifications.

Chapter 500
ELECTRIC DRIVE CONTROLLERS

510. Requirements for all Controllers.

511. GENERAL.

a. The following specifications cover controlling equipment of the nonautomatic and automatic types for electric motors driving centrifugal fire pumps. Chapter 400 dealing with the electric motor drive also applies insofar as it is appropriate.

b. Automatic-type controllers are recommended for use only where the fire pump takes its water under positive pressure and their use is not recommended where a suction lift is involved.

c. All controllers shall be specifically approved for fire pump service.

d. The control panel shall be completely assembled, wired, and tested by the manufacturer before shipment from the factory.

e. Voltages above 600 v are not recommended for fire pump service, but where it is impracticable to use a low voltage, higher voltages may be accepted by the authority having jurisdiction. High voltage controllers shall be rated at not more than 5000 v. (See Article 520).

f. Controllers conforming to this Standard shall be marked "Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation and the complete electrical rating.

512. LOCATION.

a. The controller shall be located as close to as is practical and within sight of the motor.

b. The controller shall be so located or protected that it will not be injured by water escaping from the pump or connections. Current carrying parts of the controller shall be not less than 12 inches above the floor level.

c. A clearance of not less than 3½ feet shall be provided at the rear of enclosures designed to be inspected and serviced from the rear.

513. GENERAL CONSTRUCTION.

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

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

c. ENCLOSURE. The structure or panel shall be securely mounted in an enclosure(s) which will protect the equipment against mechanical injury and falling drops of water striking the enclosure from the downward vertical.

d. CONNECTIONS AND WIRING.

1. All bus bars and connections shall be readily accessible for maintenance work after installation of the controller without disconnecting the external circuit conductors.

2. Test Connections. Provision shall be made to allow the use of test meters by one of the methods outlined in the following paragraphs (a) or (b).

(a) Terminals shall be so located and arranged that a clamp-on or such type meter can be safely and conveniently used, or

(b) There shall be provided, as part of the controller, a readily accessible test link or equivalent means for connecting a current measuring instrument in one of the motor circuit conductors without the necessity for disconnecting any conductor which runs outside the equipment enclosures. The test link shall be connected between the isolating switch and the circuit breaker.

3. Bus bars and other wiring elements of the controller shall be designed on a continuous duty basis, except that conductors which are in a circuit only during the motor starting period may be designed accordingly.

e. PROTECTION OF AUXILIARY CIRCUITS. Circuits which are depended upon for proper operation of the controller shall not have over-current protective devices connected in them.

f. 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 the National Electrical Code (NFPA No. 70). The isolating switch shall meet the requirements of Section 514.

g. WIRING DIAGRAMS AND INSTRUCTIONS.

1. A wiring diagram shall be provided and permanently attached to the inside of the enclosure.

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

h. MARKING. Each motor control device and each switch and circuit breaker shall be marked to plainly indicate the name of the manufacturer, his 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.

i. INSTRUCTIONS. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller. Pump operators should be familiar with these instructions and should observe in detail all of their provisions.

514. COMPONENTS.

a. ISOLATING SWITCH. Except as noted in Paragraph 531b for limited service controllers, a manually operated isolating switch shall be provided within the enclosure, connected on the supply side of the circuit breaker with one pole for each branch circuit conductor.

1. The switch shall be externally operable (see 513f) and the operating handle shall be provided with a spring latch which will not interfere with the closing of the switch, but shall be so arranged that it requires the use of the other hand to hold the latch released in order to permit the opening of the isolating switch.

2. The ampere rating of the switch shall be at least 115 per cent of the nameplate current rating of the motor.

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

WARNING — DO NOT OPEN OR CLOSE THIS

SWITCH WHILE THE CIRCUIT BREAKER (DISCONNECTING MEANS) IS IN CLOSED POSITION.

b. CIRCUIT BREAKER (DISCONNECTING MEANS). Except as noted in Section 532 for limited service controllers, the motor branch circuit shall be protected by a suitable magnetic trip-type circuit breaker, connected directly to the load side of the isolating switch and conforming with the following requirements:

1. No other overcurrent protective devices shall be in the motor circuit on the load side of the circuit breaker.

NOTE: See Article 433 for rating and setting of overcurrent devices in the circuit on the line side of the circuit breaker. See National Electrical Code (NFPA No. 70) for the number of overcurrent units required for circuit protection devices.

2. It shall have one pole for each ungrounded branch circuit conductor.

3. It shall be externally operable (see 513f).

4. It shall trip free of the handle.

5. Its rating shall not be less than 115 per cent of the rated full load current of the motor.

6. It shall permit normal starting of the motor without tripping.

7. It shall provide stalled rotor and instantaneous short circuit protection.

(a) For a squirrel cage induction motor, it shall be of the time delay type and have a time delay of not over 20 seconds at locked rotor current (this is 600 per cent of rated full load motor current for squirrel cage induction motors), and shall be calibrated up to and set at 300 per cent of the motor full load current.

(b) For a direct-current motor and wound rotor alternating-current motor, it shall be of the instantaneous type calibrated and set at 400 per cent of the motor full load current.

8. Its interrupting rating shall be adequate for the circuit in which it is used, and in no case be less than 14,000 amperes (symmetrical).

9. The required interrupting rating should be ob-

TABLE 514.

Interrupting Capacity of Circuit Breakers of Fire Pump Controllers When the Electric Supply is Through Transformers

(See Paragraph 514b.8 for general rule for determining the interrupting capacity of circuit breakers of fire pump controllers.)

Capacity of Transformer Bank kva.	Transformer Secondary Voltage	Length of Fire Pump Branch Circuit Feet	I.C. of Cir. Br. of Fire Pump Controller — Amperes Symmetrical: No branch Cir. Br. (See Fig. 430 A-1 and A-2)	I.C. of Cir. Br. of Fire Pump Controller — Amperes Symmetrical: With branch Cir. Br. (See Fig. 430 A-3 and A-4)
FIRE PUMP MOTORS OF 75 HP. OR LESS				
750	240	50-75	22000	14000
750	240	Over 75	14000	14000
1000	240	50-85	22000	14000
1000	240	Over 85	14000	14000
1500	480	50-75	22000	14000
1500	480	Over 75	14000	14000
1500	240	50-100	22000	14000
1500	240	Over 100	14000	14000
2000	600	25-65	22000	14000
2000	600	Over 65	14000	14000
2000	480	50-85	22000	14000
2000	480	Over 85	14000	14000
2000	240	20-54	42000	22000
2000	240	55-105	22000	14000
2000	240	Over 105	14000	14000
FIRE PUMP MOTORS OF 100 HP. AND 125 HP.				
1000	240	50-110	22000	14000
1000	240	Over 110	14000	14000
1500	480	50-110	22000	14000
1500	480	Over 110	14000	14000
1500	240	25-65	42000	22000
1500	240	66-125	22000	14000
1500	240	Over 125	14000	14000
2000	600	20-55	42000	22000
2000	600	56-135	22000	14000
2000	600	Over 135	14000	14000
2000	480	20-60	42000	22000
2000	480	61-135	22000	14000
2000	480	Over 135	14000	14000
2000	240	30-80	42000	22000
2000	240	81-140	22000	14000
2000	240	Over 140	14000	14000

tained by the purchaser based upon the maximum possible short-circuit current at the pump room. The values, which are approximate, shown in Table 514 may be used as a guide.

10. A nameplate with the legend CIRCUIT BREAKER — DISCONNECTING MEANS in letters not less than ⅜-inch high shall be located on the outside of the enclosure adjacent to the means for tripping the circuit breaker.

c. MOTOR STARTER. The motor starter shall be of the magnetic type with a contact in each conductor.

1. For electrical operation of reduced voltage starters, timed automatic acceleration of the motor shall be provided and the period of motor acceleration shall not exceed 10 seconds.

2. 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.

3. 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.

d. ALARMS AND SIGNAL DEVICES (ON CONTROLLER). A 6w or 7w candelabra base 115-125 v. 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) to indicate that the circuit breaker and test link are closed and that power is available at the controller for starting. The lamp shall be accessible for replacement.

NOTE: It is recommended that the lamp operating voltage be less than the rated voltage of the lamp to insure long operating life. When necessary, suitable resistors or potential transformers should be used to reduce the voltage for operating the lamp.

e. ALARM AND SIGNAL DEVICES (REMOTE). Where the pump room is not constantly attended, the controller shall be equipped with contacts to operate circuits, not exceeding 125 volts, for audible or visual alarms at a point of constant attendance indicating the following:

1. Controller has operated into a pump running condition.

2. Loss of line power on line side of motor starter in any phase. This may be accomplished through use of

drop out type relays controlling an alarm circuit energized by a reliable source of power supply. The relay contacts should close on failure of voltage. Unless the power to this alarm circuit is electrically supervised, the controller shall be arranged to start upon failure of this alarm circuit power.

515. STARTING AND CONTROL.

a. The following definitions are from the National Electrical Code (1968):

1. Nonautomatic: Nonautomatic means that the implied action requires personal intervention for its control.

As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

2. Automatic: Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

b. NFPA No. 20 contemplates that:

1. Nonautomatic controller shall be actuated by electrical manual and mechanical manual means.

2. Automatic controller shall be operable as a nonautomatic controller and also by other nonpersonal means such as: low water pressure, tripping of deluge and dry pipe valves, etc.

c. NONAUTOMATIC

1. Manual Electric Control at Controller: There shall be a manually operated switch on the control panel so arranged that when the pumping unit is started manually, its operation cannot be affected by the pressure switch, and so that the unit will remain in operation until manually shut down, except that an autotransformer reduced-voltage type of starter need not have electrical control means for starting the motor.

2. 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, but such stations shall not be operable to stop the unit.

3. 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 for nonautomatic continuous running operation of the motors independent of any electric control circuits or 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 with the exception of the autotransformer reduced-voltage type starter.

(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.

d. AUTOMATIC

1. Water Pressure Control: An acceptable type pressure switch having independent high and low calibrated adjustments, and which is responsive to water pressure in the fire system shall be provided in the control circuit.

NOTE: Test Device: Suitable provision shall be made for relieving pressure to the pressure switch to test the operation of the controller and the pump (Figure 515d.1, Appendix C).

2. Fire Protection Equipment Control: When the pump supplies special water control equipment (deluge, dry pipe valves, etc.) and it is desired to start the pump before the pressure control(s) would do so, the authority having jurisdiction may require the controller to be equipped to start the pump upon operation of the fire protection equipment. The controller shall be equipped with a relay of the drop-out type to start the pump when the fire protection equipment operates. The relay shall be actuated from a normally closed contact on the fire protection equipment.

NOTE: Deluge System Operation: Where the pump supplies a deluge system the authority having jurisdiction may require the controller to be equipped with a relay of the drop-out type to start the pump when the deluge valve trips. The relay should be actuated from a normally closed contact on the deluge valve.

3. Sequence Starting: Controllers for multiple pump units shall incorporate a sequential timing device to prevent any one pump starting simultaneously with any other pump. If the water requirements are such that more than one pump operates, the units shall start in 5-second intervals or at intervals which will not permit a subsequent starting pump to start until the previous pump has reached full speed. Failure of a leading pump to start shall not prevent subsequent pumps from starting.

4. For sprinkler systems and standpipe systems where an automatically controlled pump constitutes the sole supply or where required by the authority having jurisdiction, the controller shall be wired for automatic start and manual shutdown.

e. METHODS OF STOPPING: Shutdown may be accomplished by either one or both of the following:

1. Manual — the control panel shall have means for electrical operation for stopping the motor which in case of automatic controllers will return the controller to full automatic position.

2. Automatic — after starting causes have returned to normal and the pumping unit has operated for the time fixed by the running period timer.

NOTE: Whenever the controller is arranged for automatic shutdown, a running period timer set for one minute for each ten horsepower of motor rating, but not to exceed 7 minutes, shall be installed.

520. Requirements for Controllers for Voltages in Excess of 600 Volts.

521. CONTROL EQUIPMENT. Where equipment rated in excess of 600 volts is permissible (see Section 511) the control equipment shall comply with the requirements of Article 510 except as indicated in Sections 522 through 528.

522. PROVISIONS FOR TESTING. The provisions of Paragraph 513d.2 shall not apply, but an ammeter with a suitable transfer switch arranged for reading the current in each phase shall be provided on the controller. An indicating voltmeter with scale calibrated to the high voltage

supply and deriving its source of power from the control transformer secondary shall also be provided on the controller.

523. DISCONNECTING UNDER LOAD. Provision shall be made to prevent opening the isolating switch under load.

524. LOCATION OF PRESSURE ACTUATED SWITCH. Special precautions should be taken with regard to the location of the pressure actuated switch called for in Paragraph 515d(1) to prevent any water which may be present due to leakage from coming in contact with high-voltage components.

525. 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 supply shall be interrupted when the isolating switch is in the open position.

526. PILOT LAMP. For these controllers Section 514d shall be replaced by the following:

A pilot lamp shall be provided to indicate that power is available. The lamp operating voltage shall be less than the lamp voltage rating to insure long life. The supply for the lamp shall be obtained from the secondary of the control circuit transformer through resistors, if found necessary, or a small capacity step-down transformer to reduce the control transformer secondary voltage to that required for the pilot lamp.

527. PERSONNEL PROTECTION FROM HIGH VOLTAGE. The necessary provisions shall be made, including such interlocks as may be needed, to protect the personnel from accidental contact with high voltage.

528. INTERRUPTING CAPACITY. The circuit breaker, or the controller where it also performs the function of the circuit breaker, shall have adequate kilovolt ampere interrupting capacity for the intended service.

530. Limited Service Controllers.

531. APPLICATION. This section is applicable to automatic controllers for across-the-line type squirrel cage mo-

tors of 30 horsepower or less, 600 volts or less, where such use is acceptable to the authority having jurisdiction. All of the requirements of the preceding sections apply except as indicated in the following:

a. MARKING. Each motor controller shall be marked as specified in Paragraph 511f except that the title will be "Limited Service Controller."

b. The manually operated isolating switch mentioned in 514a is not required.

532. CIRCUIT BREAKER. The circuit breaker shall conform to 514b with the following changes:

a. It shall be approved for disconnect purposes.

b. It need not be a magnetic trip type. In general, the rating of a direct heated thermal element breaker should be the standard rating at or next below 250 per cent of the motor full-load current, but not smaller than 150 per cent; and the rating of an indirect heated thermal element breaker should be the standard rating at or next above 125 per cent of the motor full load current.

c. The calibration shall be of the fixed type to discourage adjusting and tampering by unauthorized persons.

d. The interrupting rating of the breaker shall be not less than 10,000 amperes.

Chapter 600.
INTERNAL COMBUSTION ENGINE DRIVE.

610. General.

611. RECOMMENDED USE. a. Selection of internal combustion engine type fire pump equipment for each situation should be based on careful consideration of factors of the most reliable type of control, ignition and fuel (including fuel supply), the starting operation and the running operation of the internal combustion engine.

b. The compression ignition diesel engine is one of the most dependable sources of power for driving fire pumps. Spark ignition type engines are advised as supplemental units with natural gas and gasoline as acceptable fuels in that order of preference.

620. Engines.

621. APPROVAL. Engines shall be specifically approved for fire pump service.

622. RATINGS.

a. The engine shall have a bare engine brake horsepower rating at least 20 per cent greater than the maximum brake horsepower required to drive the fire pump at rated revolutions per minute of the pump unit.

NOTE: The 20 per cent excess power takes account of the fact that new production engines are permitted to run as low as 5 per cent under the official bare engine horsepower curve and that up to 5 per cent may be needed for operation of accessories, allowing at least 10 per cent reserve power for reliability of performance and for normal depreciation of the engine with age and use.

b. A deduction of 5 per cent of the power shown on the curve of the engine, having a standard sea level compression ratio, shall be made for each 1,000 feet rise in altitude above sea level. This correction should be made prior to any other power deductions or rating correction factors.

c. When the authority having jurisdiction permits the use of gear drives between the pump and its driver, (see 623a.) the horsepower requirement of the pump should be increased to allow for power losses.

d. Engines listed for fire pump service by a nationally recognized testing laboratory may be accepted for horsepower ratings established by the laboratories.

623. CONNECTION TO PUMP.

a. Except where otherwise permitted by the authority having jurisdiction the engine shall be directly connected to a horizontal pump by means of a flexible coupling of suitable design. Vertical shaft turbine-type pumps shall have the engine connected to the right angle drive with suitable universal joints.

b. Dual drive units are not recommended. The use of separate pumps provides greater flexibility and reliability. Where dual drive is used, the coupling should be of an automatic type acceptable to the authority having jurisdiction and the engine drive shall be equipped with an approved free-wheeling clutch. If the other drive is an electric motor, it too shall be equipped with an approved free-wheeling clutch.

624. INSTRUMENTATION AND CONTROL.

a. GOVERNOR. An adjustable governor shall be provided for the engine to regulate the speed within a range of 10 percent between shutoff and maximum load conditions of the pump. It shall be set to maintain rated pump speed at maximum pump load.

b. EMERGENCY GOVERNOR. An emergency governor shall be provided for a diesel engine. It should be arranged to shut down the engine at a speed approximately 20 percent above rated engine speed. The emergency governor shall be arranged for manual reset.

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

d. OIL PRESSURE GAGE. An oil pressure gage shall be provided to indicate engine lubricating oil pressure.

e. TEMPERATURE GAGE. A temperature gage shall be provided to indicate engine cooling water temperature.

f. CONTROL PANEL. All instruments of control such as gages, switches, indicators and coils should be placed on a suitable board secured to the unit at a suitable point.

g. FACTORY WIRING — AUTOMATIC CONTROLLER. All

connecting wires for the automatic controller 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 automatic controller, for ready wiring in the field between the two sets of terminals.

h. MAIN BATTERY CONTACTORS. Main battery contactors shall be manually operable in case of control circuit failure.

625. STARTING METHODS.

a. Compression ignition diesel engines should preferably be equipped with an electric starting device taking current from a storage battery, but may be started by other reliable means.

b. If air starting of diesel engines is used with air pressure in excess of 100 pounds gage pressure, the air tanks shall be so located or guarded as not to be subject to mechanical injury. For air starting there shall be at least two containers each sufficient for six consecutive starts without recharging. There shall be a separate air compressor, suitably powered, or means of obtaining air from some other system shall be installed, independent of any compressor driven by the engine operating the fire pump. Automatic maintenance of air pressure is preferable, but in all cases suitable supervisory service shall be maintained to indicate high and low pressure conditions.

c. If a gasoline starting engine is used to crank the diesel engine, or gasoline is used in connection with electric ignition, the handling and storage of gasoline shall be as required for gasoline engine driving of centrifugal fire pumps.

NOTE: Electric current for ignition may be taken from the storage battery or from a high tension magneto.

d. Gasoline engines shall be equipped with an electric starting device taking current from the storage battery.

626. STORAGE BATTERY.

a. GENERAL. The battery shall have sufficient capacity, at 40°F., to maintain the engine manufacturers recommended cranking speed during the following 6 minute cycle (15 seconds crank and 15 seconds rest in 12 consecutive cycles). The fire pump manufacturer shall provide a certification that the battery which was furnished complies with this requirement.

b. LEAD ACID. Batteries shall be furnished in a dry charge condition with electrolyte liquid in separate container. Electrolyte should be added at the time the unit is put into service. The battery shall then be given a conditioning charge to bring the electrolyte up to its designated specific gravity.

c. NICKEL CADMIUM. A nickel cadmium alkaline type battery may be used where desired in place of the lead acid battery described above.

d. RECHARGING. Two ways of recharging storage batteries shall be provided. One shall be the generator furnished with the engine. The other shall be an automatically controlled charger taking power from an alternating power source. (Other charging methods must be specified if a reliable alternating power source is not available.)

e. CHARGERS.

1. All chargers shall be specifically approved for fire pump service.

2. The rectifier shall be of the semiconductor type.

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

4. The control equipment incorporated in an "off-on" type of charger for a lead acid battery shall start the rectifier hourly and automatically shut off when the battery has been fully charged.

5. The charger for a lead acid battery shall be capable of delivering a current within the range of 50 to 100 per cent of the 20-hour discharge rate of the battery.

6. The above charging rates apply to lead acid batteries and should be modified in accordance with the battery manufacturer's recommendation when nickel-cadmium batteries are supplied.

7. An ammeter of an accuracy of 5 per cent of the normal charging rate shall be furnished to indicate the operation of the charger.

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

9. A single charger that automatically alternates

from one battery to another on an hourly cycle may be used on two battery installations.

10. A manual charge switch with indicator light shall be provided or in lieu thereof, the charge shall automatically charge at the maximum rate when required by the state of charge of the battery.

f. LOCATION.

Storage batteries shall be substantially supported, secured against displacement, and located where they will not be subject to excessive temperature, vibration, mechanical injury, or flooding with water, and are readily accessible for servicing. Location at the side of and level with the engine is recommended to minimize battery to starter lead length.

627. COOLING.

a. The engine cooling system shall be of the closed circuit type including a circulating pump driven by the engine, a heat exchanger and a reliable engine jacket temperature regulating device ("Fail-Safe" type of thermostat). An opening shall be provided in this circuit for filling the system, checking coolant level, and adding make-up water when required.

b. The cooling water supply for the heat exchanger shall be from the discharge of the fire pump taken off prior to the pump discharge valve. Threaded rigid piping shall be used. The pipe connection shall include a manual shut-off valve, a strainer, a pressure regulating valve, an automatic electric solenoid valve (when required) and a second manual shut-off valve. Provision should be made for a pressure gage to be installed in the cooling water supply system on the engine side of the last control valve.

c. A by-pass line with a manual valve shall be installed around the manual shut-off valve, strainer, pressure regulating valve, automatic solenoid valve (when required) and second manual shut-off valve. (See Figure 627.)

d. An outlet shall be provided for the waste water line from the heat exchanger, and the line shall be at least one size larger than the inlet line. The outlet line shall be

short, with the discharge into a visible open waste cone, and no valves shall be used in this line.

e. A water jacketed (cooled) exhaust manifold shall be used since no fan is available to dissipate heat and to avoid hazard to operators or flammable material adjacent to the engine. This exhaust manifold should be cooled by raw water discharging from the heat exchanger.

628. CARBURETION.

a. If a down-draft carburetor is used, suitable provision shall be made in addition to the carburetor float valve to prevent delivery of liquid gasoline to the engine cylinders.

NOTE: This is usually accomplished by a drain from the intake manifold. This should be piped to a safe location.

b. The carburetor drip cup drain should be piped at its lower end to a safe location.

629. ANTI-DIESELING DEVICES.

a. Anti-dieseling devices. A reliable and effective anti-dieseling device shall be provided on automatically controlled spark-ignited gasoline engines with a displacement of 350 cubic inches and larger to insure positive shutdown without dieseling. Control for the device shall be provided by the automatic engine controller or supplemental accessories to the controlled engines.

b. Less than 350 cubic inch displacement engines shall also be equipped with this device unless approval tests show that it is unnecessary.

630. Location.

631. CONSTRUCTION.

a. While it may not always be possible to locate a fire pump driven by an internal combustion engine in a separate pump house it is in every case highly important that the pump room be wholly cut off by noncombustible construction of a heavy character.

b. Floors should be pitched for adequate drainage of escaping water or fuel away from critical equipment such as pump, driver, controller, fuel tank, etc.

c. Where fire pumps constitute the entire water supply or where they constitute the major water supply, gasoline engine driven fire pumps located in the same room with fire pumps driven by other methods should, because of their possible fire hazard, have a heat resistant barrier wall to isolate the gasoline engines from other pumping units.

632. VENTILATION

a. Means for thorough ventilation shall be provided, adequate for engine air supply and for removal of hazardous vapors.

b. Gasoline engine driven fire pump units should not be installed in depressed pump rooms. Installation shall be such that escaping gasoline vapors cannot accumulate in the pump room or vicinity.

640. Fuel Supply Arrangement

641. REVIEW OF PLAN. Before any system is installed the authority having jurisdiction should be consulted as to the system proposed to the end that the suitability of the system for conditions be determined.

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

643. DIESEL.

a. CAPACITY DIESEL FUEL SUPPLY. The capacity of the main diesel fuel supply tank shall be determined by conditions and subject to special consideration in each case by the authority having jurisdiction; minimum storage capacity shall be sufficient to operate the engine for at least eight hours, and a greater capacity should be provided in places where prompt replenishment of supply is unlikely. There shall be a separate fuel line and fuel tank for each engine. Where multiple engine driven pumps are used, the fuel lines shall be interconnected and valved so that all engines may continue to operate even though one or more fuel tanks may be out of service.

Note: Allow one pint of diesel fuel per horsepower per hour.

b. LOCATION DIESEL FUEL SUPPLY. The tank shall be located in accordance with municipal ordinances, and requirements of the authority having jurisdiction. Means

shall be provided for determining the amount of fuel in the storage tank. The tank should have suitable filling and vent connections.

c. DIESEL FUEL PIPING. NFPA Standard for the Installation of Oil Burning Equipment (No. 31) may be used as a guide. A suitable flexible connection of approved metallic type shall be provided in the fuel line where it connects to the engine fuel piping. No shutoff valve shall be installed in the fuel return line to the tank. (See Figs. 643a and 643b for suggested arrangements.)

644. NATURAL GAS.

a. RELIABILITY OF SUPPLY. Reliability of the fuel supply is essential. Natural gas can be considered an acceptable fuel only where arrangements can be made for maintaining the fire pump gas supply at all times even when restrictions are applied by the supplier to other uses of the gas. Piping shall be adequate to maintain the required pressure at the fire pump under conditions of maximum demand for other uses. Provision must be made for automatic cut-off in case of a break in the plant service line to insure an uninterrupted supply to the fire pump.

NOTE: Allow 12 cubic feet of 1,000 BTU natural gas per horsepower per hour.

b. BTU CONTENT. The BTU value of the natural gas shall be equal to or greater than that specified by the engine manufacturer for the maximum rated load or allowance shall be made in the rated horsepower of the engine to adjust for the variation.

c. PRESSURE REGULATOR. An approved regulator shall be provided to reduce available natural gas pressure to the low pressure for satisfactory operation of the engine carburetor.

d. FEED. There shall be an electric opening, self-closing safety shutoff valve installed in the fuel line on the engine. This valve shall open when the engine ignition is turned on and close automatically when the ignition is turned off. There shall be a manual valved bypass around this valve in the event of malfunction of the safety shutoff valve and the bypass valve shall be provided with a visual or audible signal to show when it is open. All electric controls shall be powered by the engine pumping unit electrical system. (See Fig. 644.)

e. PIPING. All exterior and interior gas piping shall be in accordance with recommendations of Standard for

the Installation of Gas Appliances and Gas Piping, NFPA No. 54. There shall be a manually operated outside shutoff valve in the gas supply line, locked open with a breakable lock. All piping outside the pump house shall be installed with pitch to drain so as to avoid any possible water trap or pocket. There shall be a suitable flexible connection of approved metallic type in the fuel line where it connects to the engine fuel piping.

645. GASOLINE.

a. CAPACITY GASOLINE SUPPLY. The capacity of the main gasoline supply tank shall be determined by conditions and subject to special consideration in each case by the authority having jurisdiction; minimum storage capacity shall be sufficient to operate the engine for at least 8 hours and a greater capacity should be provided in places where prompt replenishment of supply is unlikely.

NOTE: Allow one pint of gasoline per horsepower per hour.

b. LOCATION GASOLINE SUPPLY. The tank shall be located outside the pump room and in accordance with municipal ordinances, and requirements of the authority having jurisdiction. The tank should be so located with respect to pumps drawing gasoline therefrom that the maximum lift will not exceed 6 feet. The fuel tank for an automotive type engine should preferably be installed so that the top of the tank is about on a level with the carburetor. Means shall be provided for determining the amount of gasoline in the storage tank. The tank should have suitable filling and vent connections.

c. GASOLINE FEED.

1. The gasoline shall be fed to the carburetor by a method which will be dependable and safe. The following suggested arrangement may be modified to suit the conditions, subject to approval by the authority having jurisdiction.

2. A pumping system utilizing a gasoline pump, furnished as a part of the engine, which draws gasoline from the storage tank and delivers it to the carburetor. The gasoline pump should be capable of pumping gasoline at a rate of at least 1½ times the amount needed for the engine while running at rated speed and load. As a supplementary supply there shall also be provided a hand gasoline pump connected to draw gasoline from the storage tank and deliver

it to a two-quart tank from which the carburetor may be supplied by gravity. (See Fig. 645.)

646. GASOLINE PIPING. All gasoline piping between tanks and between tanks and engines shall be approved seamless copper tubing with flared joints. Fuel pump suction lines shall be at least ⅜ inch in size. A suitable flexible connection of approved metallic type shall be provided in the fuel line where it connects to the engine fuel piping.

650. Exhaust Piping

651. EXHAUST PIPING. Exhaust from the engine shall be piped to a safe point outside the pump room and arranged to exclude water. A seamless or welded corrugated (not interlocked) flexible connection shall be made between the engine exhaust outlet and the exhaust pipe. The exhaust pipe shall be as short as possible and not over 15 feet unless the size of exhaust pipe is increased at least one pipe size, and shall be properly insulated from combustible material. Muffler, receiving vessel or other attachments which may accumulate unburned gases are not recommended, but if used shall not be located in the pump room. Exhaust gases should not be discharged where they will affect persons or endanger buildings, flues or stacks. A free and independent exhaust is essential to the reliability of the equipment.

660. Maintenance.

661. GENERAL. Internal combustion engines necessarily embody moving parts of such design and in such number that the engines cannot give reliable service unless given intelligent care. The manufacturer's instruction book covering care and operation should be preserved and pump operators should be familiar with its contents and should observe in detail all of its provisions.

662. WEEKLY RUN. The engine shall be started at least once a week and run for at least thirty minutes to bring it up to normal running temperature and to make sure that it is running smoothly at rated speed.

663. FUEL TANK. The fuel storage tank shall be kept well supplied. This tank should always be filled through a strainer funnel designed to withhold any water or other

foreign matter that may be present. Any service tank shall also be kept full.

NOTE: Gasoline deteriorates with age. It is therefore desirable that gasoline storage tanks be drained and refilled with fresh supply at least once each year. The occasional use of an upper lubricant is desirable for smooth operation of the engine and preventing sticking valves.

664. ENGINE UPKEEP. The engine should be kept clean, dry and well lubricated, and the proper oil level should be maintained in the crankcase. Oil should be changed in accordance with engine manufacturer's recommendations, but at least annually.

665. STORAGE BATTERIES.

a. Storage batteries should be kept charged at all times and tested frequently with a hydrometer to ascertain the condition of the cells and the amount of charge in the battery.

b. Distilled water only should be used in storage battery cells and the plates should be kept submerged at all times.

c. An automatic battery charger is not a substitute for proper maintenance of the battery and charger. Periodic inspection of the battery and the charger shall be made. This inspection should determine that the charger is operating correctly, the water level in the battery is correct, and the battery shall be checked by means of a hydrometer to show it is maintaining its proper charge.

666. TEMPERATURE.

a. Pump room temperatures must be maintained above 40° F. (see 41e).

b. Diesel engines, at temperatures below 70° F, may require some form of starting aid as recommended by the engine manufacturer.

c. Automatically started engines should be installed in enclosed pump rooms where a minimum temperature of 60° F for gasoline engines and 70° F for diesel engines is maintained.

d. Since fire pump engines must carry full load as soon as started, automatic heaters should be employed to

maintain jacket water temperatures of liquid cooled engines at (a minimum of 120° F) or near operating temperatures. This may be accomplished through the circulation of hot water through the jacket or through heating of engine water by electric elements inserted into the block. The benefits to be gained are (1) quick starting, (2) reduction in engine wear, (3) reduced drain on batteries, (4) reduced oil dilution, (5) reduction in carbon deposits, and (6) with gasoline fueled engines it becomes possible to adjust the automatic choke so that the engine is far more likely to start every time.

667. PARTS. Spare parts of such portions of the machine as may be expected to give trouble should be kept on hand.

Chapter 700

ENGINE DRIVE CONTROLLERS

710. Requirements for All Controllers.

711. GENERAL.

a. The following specifications cover controlling equipment of the combined nonautomatic and automatic types for internal combustion engines driving centrifugal fire pumps. Chapter 600 dealing with the internal combustion engine drive also applies where appropriate.

b. Automatic-type controllers are recommended for use only where the fire pump takes its water under positive pressure and their use is not recommended where a suction lift is involved.

c. All controllers shall be specifically approved for fire pump service.

d. The control panel shall be completely assembled, wired and tested by the manufacturer before shipment from the factory.

e. Controllers conforming to this Standard shall be marked "Fire Pump Controller" and shall show plainly the name of the manufacturer, the identifying designation and the complete electrical rating.

f. The services of a representative of the manufacturer may be required for installation and adjustment of the equipment. It shall be the responsibility of the installing contractor to make the necessary arrangements for this service.

712. LOCATION.

a. The controller shall be located as close to as is practical and within sight of the engine.

b. The controller shall be so located or protected that it will not be injured by water escaping from the pump or connections.

c. A clearance of not less than 2½ feet shall be provided at the rear of enclosures designed to be inspected and serviced from the rear.

713. GENERAL CONSTRUCTION.

a. 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.

NOTE: In areas affected by excessive moisture, heat may be useful in reducing the dampness.

b. MOUNTING. All equipment except engine mounted shall be mounted in a substantial manner on a single, noncombustible supporting structure.

c. ENCLOSURE. The structure or panel shall be securely mounted in an enclosure(s) which will protect the equipment against mechanical injury and falling drops of water striking the enclosure from the downward vertical.

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

e. WIRING DIAGRAMS.

1. A wiring diagram shall be provided and perma-

nently attached to the inside of the enclosure showing exact wiring for this controller including a legend of identifying numbers of individual components.

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

f. CONNECTIONS AND WIRING.

1. Wiring elements of the controller shall be designed on a continuous duty basis, except that conductors which are in a circuit only during the engine starting period may be designed accordingly.

2. Field Wiring. All wiring leading from the panel to the engine and batteries shall have adequate carrying capacity and shall be protected against mechanical injury. Controller manufacturer's specifications regarding distance and wire size shall be followed.

g. 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.

h. INSTRUCTIONS. Complete instructions covering the operation of the controller shall be provided and conspicuously mounted on the controller. Pump operators should be familiar with these instructions and should observe in detail all of their provisions.

714. COMPONENTS.

a. ALARM AND SIGNAL DEVICES (On Controller)

1. A pilot lamp(s) shall be provided in the line side of the starting equipment circuit to indicate that the controller is in the "automatic" position with power available for starting. The lamp shall be accessible for replacement.

NOTE: It is recommended that the lamp operating voltage be less than the rated voltage of the lamp to insure long operating life. When necessary, suitable resistors should be used to reduce the voltage for operating the lamp.

2. A pilot lamp shall be provided in each battery supply to indicate that batteries are connected to the controller and are at least partially charged when the controller is set in the automatic position.

3. Pilot lamps and a common bell shall be provided to indicate trouble caused by:

(a) 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 water temperature.

(c) Failure of engine to start automatically.

(d) Shutdown from overspeed (diesel only).

b. ALARM AND SIGNAL DEVICES (remote). Where the pump room is not constantly attended, the controller shall be equipped with contacts (open or closed) to operate circuits powered by a source other than engine starting batteries, not exceeding 125 volts, for audible or visual alarms at a point of constant attendance indicating the following:

1. Controller has operated into a pump running condition. (separate signal)

2. Controller main switch has been turned to "off" or "manual" position (separate signal).

3. Trouble on the controller or engine: (A common signal may be used for trouble indication)

(a) Items in 714.a.3.

(b) Loss of A.C. power to the battery chargers and controller. This may be accomplished through use of a drop-out type of relay. The relay contacts should close on failure of voltage. Unless the power is electrically supervised as above, the controller should be arranged to start upon failure of this power. (See Paragraph 715.d.6)

715. STARTING AND CONTROL.

a. DEFINITIONS (from the National Electrical Code, 1968 Edition).

1. Nonautomatic — Nonautomatic means that the implied action requires personal intervention for its control.

As applied to an electric controller, nonautomatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

2. Automatic — Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature or mechanical configuration.

b. This Standard contemplates that:

1. Nonautomatic controller shall be actuated by electrical manual means.

2. Automatic controller shall be operable as a nonautomatic controller and also by other nonpersonal means such as: low water pressure, tripping of deluge and dry pipe valves, etc.

c. NONAUTOMATIC.

1. Manual Electric Control at Controller. There shall be a manually operated switch on the control panel. This switch shall be so arranged that when the pumping unit is started manually, its operation cannot be affected by the pressure switch so that the unit will remain in operation until manually shut down.

2. 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, but such stations shall not be operable to stop the unit except through the established operation of the controller.

d. AUTOMATIC.

1. Water Pressure Control. An acceptable type pressure switch having independent high and low calibrated adjustments and which is responsive to water pressure in the fire system shall be provided in the control circuit.

NOTE: Test Device. Suitable provision must be made for relieving pressure to the pressure switch to test the operation of the controller and the pump. (Figure 515 d. 1. Appendix C.)

2. Fire Protection Equipment Control. When the pump supplies special water control equipment (deluge, dry pipe valves, etc.) and it is desired to start the pump before the pressure control(s) would do so, the authority having jurisdiction may require the controller to be equipped to start the pump upon operation of the fire protection equipment. The controller shall be equipped with a relay of the drop-out type to start the pump when the fire protection equipment operates. The relay shall be actuated from a normally closed contact on the fire protection equipment with this circuit supplied by the batteries.

3. Sequence Starting. Controllers for multiple

pump units shall incorporate a sequential timing device to prevent any one pump starting simultaneously with any other pump. If the water requirements are such that more than one pump operates, the units shall start at intervals which will not permit a subsequent starting pump to start until the previous pump has reached full speed. Failure of a leading pump to start shall not prevent subsequent pumps from starting.

4. For sprinkler systems and standpipe systems where an automatically controlled pump constitutes the sole supply or where required by the authority having jurisdiction, the controller shall be wired for automatic start and manual shutdown.

5. Weekly Program Timer. To assure dependable operation of the pumping unit and its controller, the controlling equipment may be arranged to automatically start the unit at least once a week. A solenoid drain valve on the pressure control line shall be the initiating means. Such performance may be automatically indicated on a recording pressure gage.

6. Power Failure Start. The controller may be equipped with a power failure relay, which shall be time delayed, to start the unit upon loss of A.C. power to the battery chargers and timers. (See Paragraph 714.a.3(b).)

e. STARTING EQUIPMENT ARRANGEMENT.

1. Two storage batteries, each complying with the requirements of Section 626, shall be provided and so arranged that manual and automatic starting of the equipment can be accomplished with either battery. The starting current shall be furnished by first one battery and then the other on successive operations of the starter. The change-over must be made automatically, except for manual start.

2. In the event that the engine does not start after approximately six attempts have been made, or after approximately 1½ minutes of cranking, the controller shall stop all further cranking and operate the trouble lamp and bell.

3. In the event that one battery is nonoperative, the control shall lock-in on the remaining battery during the cranking sequence.

4. Circuits shall be provided in the controller to operate chokes or similar devices where required on spark ignited engines.

5. When dual drive units are used and one or both are under automatic control, see Paragraph 623.b. Breakage or disconnection of any wires that interconnect the electric motor control and the engine control, or failure of either power source and/or controller shall not interfere with the proper operation of the other power source and/or its controller.

f. METHODS OF STOPPING. Shutdown may be accomplished by either one or both of the following:

1. Manual — by operation of the selector switch on the controller or other shutdown features.

2. Automatic Shutdown after Automatic Start:

(a.) Normal — after starting causes have been returned to normal and the pumping unit has operated for the time fixed by the running period timer. Whenever the controller is arranged for automatic shutdown a running period timer set for at least 30 minutes shall be installed.

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

3. Anti-Dieseling. Circuits shall be provided in the controller to operate anti-dieseling devices where required on spark ignited engine (see Paragraph 629).

g. EMERGENCY CONTROL. Automatic control circuits, the failure of which could prevent starting, shall be completely bypassed for manual control.

Chapter 800.
STEAM TURBINE DRIVE.

810. General Features.

811. ACCEPTABILITY.

a. Steam turbines of adequate power direct connected to fire pumps and designed to run at the same speed may be used acceptably as prime movers. The steam turbine should be one whose reliability has been proved in commercial work.

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

812. POWER.

a. For boiler pressures of 120 pounds per square inch gage or lower, the steam turbine must be capable of driving the pump at its rated speed and maximum pump load with a pressure as low as 80 pounds per square inch gage at the turbine throttle when exhausting against atmospheric back pressure, with the hand valve open.

b. For boiler pressures above 120 pounds per square inch gage where steam is continuously maintained, a steam pressure 70 per cent of the usual boiler pressure may be taken in place of 80 pounds per square inch mentioned in Paragraph 812a.

c. In ordering turbines for centrifugal fire pumps, the purchaser should state the rated and maximum pump loads at rated speed, the rated speed, the boiler pressure and if possible the pressure at the turbine throttle, and the steam superheat.

813. STEAM CONSUMPTION. Prime consideration shall be given to the selection of a turbine having a total steam consumption commensurate with the steam supply available. Single stage turbines of maximum reliability and simplicity

are recommended where the available steam supply will permit. When multistage turbines are used they shall be so designed as to allow the pump to be brought up to speed without "warm up" time being required.

820. Turbine.

821. Casing and Other Parts.

a. The casing may be of cast-iron and should be so designed as to permit access with the least possible removal of parts or piping.

b. A safety valve, to give warning of high steam pressure in the casing, shall be connected directly to the turbine casing.

c. The main throttle valve and any automatically operated 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 connected to a suitable steam trap to automatically drain all condensate from the line supplying steam to the turbine. Steam and exhaust chambers shall be equipped with suitable condensate drains which shall discharge through adequate traps where a turbine is automatically controlled. In addition, if the exhaust pipe discharges vertically there shall be an open drain at the bottom elbow, which drain shall not be valved but shall discharge to a safe location.

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

822. Speed Governor.

a. The steam turbine shall be equipped with a speed governor set to maintain rated speed at maximum pump load. The governor should 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 with normal steam pressure and hand valve closed; and at steam pressures down to 80 pounds per square inch gage, or to 70 percent of full pressure where this is in excess of 120 pounds per square inch, with hand valve open.

b. The speed governor shall be capable of adjustment while the turbine is running at rated pump load to secure speeds approximately 5 per cent above and 5 per cent below the rated speed of the pump.

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

823. AUTOMATICALLY CONTROLLED TURBINES.

a. Where the application requires a turbine driven fire pump to start automatically but where there is no desire to have the turbine on pressure control after starting, a satisfactory quick opening manual-reset valve installed in a by-pass of the steam feeder line around a manual control valve may be used.

b. Where the application requires the pump to start automatically and after starting continue to operate by means of a pressure signal, the use of a satisfactory pilot type pressure control valve located in the by-pass around the manual control valve in the steam feeder line is recommended. The turbine governor control valve when set at approximately 5 per cent above the normal full load speed of the pump under automatic control would act as a pre-emergency control.

c. In the arrangements set forth in Paragraphs 823a and b, the automatic valve should be located in the by-pass around the manual control valve that would normally be kept in the closed position. In the event of failure of the automatic valve this manual control valve could be opened allowing the turbine to come to speed and be controlled by the turbine governor control valve, or valves.

d. The use of a direct-acting pressure regulator operating on the control valve (or valves) of a steam turbine is not recommended.

824. GAGE AND GAGE CONNECTIONS.

a. An approved steam pressure gage should be provided on the entrance side of the speed-governor, and ¼-inch pipe tap for a gage connection on the nozzle chamber of the turbine.

b. The gage shall indicate pressures up to 1½ times the boiler pressure, but not less than 240 pounds per square inch, and should be marked STEAM.

825. ROTOR. The rotor of the turbine shall be of suitable material and the first unit of a design shall be type tested in the manufacturer's shop at a speed 40 per cent above rated speed. All subsequent units of the same design shall be tested at a speed 25 per cent above rated speed.

826. SHAFT.

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

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

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

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

827. BEARINGS. Turbines having sleeve bearings shall have their bearing shells and caps of the split type. Turbines with ball bearings may be accepted only after such turbines and bearings have established a satisfactory record in the commercial field. Means shall be provided to give visual indication of the oil level.

830. Installation.

831. STEAM PIPE.

a. The steam supply for the fire pump should preferably be an independent line from the boilers and should be so run as not to be liable to injury at time of fire in any part of the property. The other steam lines from the boilers should be controlled by valves located in the boiler room so that in an emergency, steam can be promptly shut off from these

lines, leaving the steam supply still available for the fire pump. Strainers in steam lines to turbines are recommended.

b. The steam throttle at the pump should close against the steam pressure and should preferably be of the globe pattern with a solid disk. If, however, the type of valve having the disk fitted with a removable composition ring is used, the disk should be of bronze and the ring made of sufficiently hard and durable material and so held in place in the disk as to satisfactorily meet severe service conditions.

NOTE: Gate valves are undesirable for this service, as they cannot so readily be made tight if leaking, as is possible with the globe type of valve. The steam piping should be so arranged and trapped that the pipes can be kept free of condensed steam.

c. In general, a reducing valve should not be placed in the steam pipe supplying the fire pump.

NOTE: There is no difficulty in designing turbines for modern high steam pressures and this gives the simplest and most dependable unit.

A reducing valve introduces a possible obstruction in the steam line in case it becomes deranged; in most cases the turbines may be protected by making the safety valve required by Paragraph 821b of such size that the pressure in the casing will not exceed 25 pounds per square inch. This valve should be piped outside of the pump room, and if possible, to some point where the discharge could be seen by the pump attendant. Where a reducing valve is used the following points should be carefully considered:

1. The valve should not contain a stuffing box or a piston working in a cylinder.

2. The reducing valve should be provided with a by-pass with a globe valve to be opened in case of an emergency. The by-pass and stop valve should be one pipe size smaller than the reducing valve, and should be located so as to be readily accessible. This by-pass should be arranged to prevent the accumulation of condensate above the valve.

3. The size of the reducing valve should be smaller than that of the steam pipe required by the specifications for the pump.

832. EXHAUST PIPE. The exhaust pipe should run direct to the atmosphere and should not contain valves of any sort. It should not be connected with any condenser, heater, or other system of exhaust piping.

833. EMERGENCY BOILER FEED.

a. A convenient method of insuring a supply of steam for the fire pump in case the usual boiler-feed supply fails, is to provide an emergency connection from the discharge of the fire pump, with a controlling valve at the fire pump and also, if desired, an additional valve located in the boiler room. A check valve also should be located in this pipe, preferably in the boiler room. This emergency connection should be about 2-inch diameter.

b. This method should not be used when there is any danger of contaminating a potable water supply.

NOTE: In situations where the fire pump is handling salt or brackish water, it may be undesirable to make this emergency boiler-feed connection. In such situations an effort should be made to secure some other secondary boiler-feed supply that will be always available.

PART III — ACCEPTANCE, OPERATION AND MAINTENANCE.

Chapter 900 — Tests and Instructions.

910. Field Acceptance Tests.

911. THOSE PRESENT. The pump manufacturer shall have an engineer present at the field acceptance tests when requested by the installing contractor.

912. The field acceptance test results shall be as good as the manufacturer's certified shop test characteristic curve for the pump being tested within the accuracy limits of the test equipment.

913. If pump takes suction under a lift, the suction pipe should be drained if possible before tests are started so that the maximum time required to start the pump with available priming facilities can be determined and conditions remedied if necessary.

914. OVERHEATING. As installed, at operating speed, the pump shall be able to operate at peak load conditions without objectionable heating of the bearings or of the prime mover. The operating pump speed shall be the speed at which the pumping unit would be expected to operate during a fire, for example:

a. A squirrel cage electric motor has no speed control and would normally drive the pump slightly in excess of rated pump speed at all loads.

b. Combustion engines and steam turbines under manual control (and automatic control where speed adjustment is easily obtained) have their speed adjusted to rated pump speed at maximum (peak) pump load.

915. OPERATING CONDITIONS.

a. By varying the number and/or size of the discharge outlets in connection with tests (Section 912) the operating conditions under minimum to peak loads shall be determined.

b. During such test:

1. For electric motors at rated voltage (and on a.c. motors at rated frequency), the full load ampere rating should not be exceeded (except as allowed by the service factor stamped on the nameplate) under any conditions of pump load.

2. For electric motors under conditions of acceptable high or low voltage, the product of the rated voltage (and on a.c. motors at rated frequency) and rated full load current will not be exceeded (except as allowed by the service factor stamped on the nameplate). The voltage at the motor should not vary more than 5 per cent below or 10 per cent above rated (nameplate) voltage during test (see Paragraph 432d).

3. An internal combustion engine shall not show signs of overload or stress and its governor shall properly regulate the speed (see Paragraphs 624a and b).

4. A steam turbine shall maintain its speed within the limits specified in Paragraphs 822 a, b, and c.

c. With discharge outlets open (corresponding to the outlets used in test at peak load) pump shall be started and brought up to rated speed without interruption due to opening of circuit breaker or other cause.

916. CONTROLLERS.

a. Manual controllers for pumps shall be put through not less than ten complete operations.

b. Combined manual and automatic controllers shall be put through not less than ten automatic and ten manual operations.

c. A running interval of at least five minutes at full speed should be allowed before repeating the starting cycle.

d. Automatic operation of the controller shall start the pump from all the provided starting features, such as pressure switches, deluge valves, etc.

e. Electric motor shall attain rated speed within ten seconds.

917. EMERGENCY GOVERNOR. On turbines for pumps the emergency governor valve shall be tripped. (Hand tripping will be accepted.)

918. LENGTH OF TEST. The pump shall be in operation not less than one hour (total time) during the foregoing tests.

921. AT THE ALARM.

a. When an alarm is given, do not wait to see how serious the fire may be, but get pump started as soon as possible and maintain its rated speed, pumping into sprinkler and hydrant systems.

b. Do not be afraid to run a centrifugal fire pump at its full rated speed, even if the demand for water is small. The characteristic curve or the relief valve will usually keep pressures within reasonable limits.

NOTE: The best way to prevent a small fire from becoming a large one is to give the sprinklers a liberal high pressure water supply at the start. Fifty open sprinklers may take the full capacity of a 750-gpm pump. Even with a good public water supply the opening of a large number of sprinklers often materially reduces the pressure so that the pumps are needed to reinforce the public supply and insure ample water at good pressure.

922. TO START A CENTRIFUGAL PUMP.

a. Never start or run a centrifugal pump before priming or first filling casing with water; otherwise the

interior wearing rings that depend on water for lubrication may be damaged and the pump made inoperative.

b. If pump is primed from a tank or other gravity supply, the pump may be started as soon as water shows at vent cocks. If primed by an exhauster, action of the device will indicate when casing is filled with water.

c. Close attention should be given to the bearings and stuffing boxes during the first few minutes of running to see that there is no heating up or need of adjustment. With water seal supplied with water, a small leak at stuffing box glands is necessary to seal, lubricate and cool the packing. The suction inlet gage as well as the discharge pressure gage should be read occasionally to see that inlet is not obstructed by a choked screen or foot valve.

923. MOTOR-DRIVEN PUMP. To start a motor driven pump the following steps should be taken in the order given below:

1. See that pump is completely primed.

2. Note that normal voltage is indicated at voltmeter.

3. Close isolating switch and *then* close circuit breaker.

4. Operate starter without undue haste, observing ammeter at each step to avoid excessively large starting currents which may cause circuit breaker to open.

NOTE: Circuit breaker tripping mechanism should be so set that it will not operate except when current in circuit is excessively large.

924. TURBINE DRIVEN PUMP. To start a steam turbine driven pump, steam should be admitted slowly at first to permit warming up of turbine casing before allowing full head of steam upon the turbine. If the pop safety valve on the casing blows, steam should be shut off and the exhaust piping examined for a possible closed valve or an obstructed portion of piping. Steam turbines are provided with governors to maintain speed at a predetermined point, with

some small adjustment for higher or lower speeds. Desired speeds below this range may be had by throttling main throttle valve.

925. INTERNAL COMBUSTION ENGINE DRIVEN PUMP.

a. To start an internal combustion engine driven pump one should familiarize himself beforehand with the operation of this type of engine. The Instruction Book issued by the engine manufacturer should be studied to this end.

b. The storage batteries should always be maintained in good order to insure prompt satisfactory operation of these equipments.

c. Replacement storage batteries shall comply with the performance requirements of Section 626.

930. Care of Pump.

931. WEEKLY TESTS. A centrifugal pump should be operated every week at rated speed with water discharging through some convenient opening. This is desirable to make sure of the condition of the pump, bearings, stuffing boxes, suction pipe and strainers, and the various other details pertaining to the driver and control equipment (see Paragraphs 515.d.1, 662, 715.d.1, and 715.d.5).

When automatically controlled pumping units are to be tested weekly by manual means at least one start shall be accomplished by reducing the water pressure either with the test drain on the pressure sensing line or with a larger flow from the entire system.

932. YEARLY TEST. A yearly test at full capacity and over is necessary, to make sure that neither pump nor suction pipe is obstructed.

933. KEEPING OF PUMP ROOM. Pump rooms should be kept clean, orderly, free from miscellaneous storage, well lighted and heated.

934. READINESS. Always keep the pump ready to start at a moment's notice.

APPENDIX A

GLOSSARY

1. The **fire pump unit** is an assembled unit consisting of a fire pump, driver, controller, and accessories.

2. The word **"controller"** is used to include the cabinet, motor starter, circuit breaker and disconnect switch and other control devices for the control of electric motor and internal combustion engine driven fire pumps.

3. The **operating suction lift** is the vertical distance in feet between the pump center line and the pumping water level (see 7 below) plus the velocity head and friction losses in the suction pipe and fittings.

4. The **total head** for a horizontal shaft fire pump is the algebraic difference between the suction head and discharge head in pounds per square inch as indicated by the gages 8 and 11 (Fig. 100a, Appendix C) located at the pump center line. If gages are not at pump center line make corrections for elevation. If the pump suction and discharge piping connections are of different sizes, corrections may be made for changes in velocity head.

The total head for a vertical shaft pump is the distance from the water level in the pit or well when pumping to the center of the discharge gage (measured in feet and converted to pounds per square inch) plus the discharge pressure gage reading measured just beyond the discharge elbow of the pump plus the velocity head at the discharge.

5. The **total rated head** for a horizontal or vertical shaft fire pump is the total head (see 4 above) developed at rated capacity.

6. The **velocity head** represents energy that the pump delivers to the liquid being pumped in achieving a certain rate of flow of the liquid ($V^2/2g$). For a given pumping condition, it is computed by measuring the flow and then choosing the value of velocity head from a curve or table according to the size of the inlet and outlet piping. For a horizontal shaft pump the difference between the velocity head at the inlet and the velocity head at the outlet is added to the discharge gage reading to find the total head of the pump. For a vertical shaft pump the velocity head is computed for the discharge piping only and added to the discharge gage reading to find the total head of the pump.

7. The **static water level** is the level, with respect to the pump, of the body of water from which the pump is taking suction when the pump is not in operation. For horizontal shaft pumps the distance to the water level is measured vertically from the pump center line. For vertical shaft pumps the distance to the water level is measured vertically from the horizontal center line of the discharge head or tee (Fig. 200a, Appendix C).

8. The **pumping water level** is the level, with respect to the pump when in operation, of the body of water from which the pump is taking suction. For horizontal shaft pumps the distance to the water level is measured vertically from the pump center line. For vertical shaft pumps the distance to the water level is measured vertically from the horizontal center line of the discharge head or tee (Fig. 200a).

9. **Draw-down** is the vertical distance between the static and pumping water levels.

10. A **wet pit** is 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.

11. **Ground water** is that water which is available from a well driven into water-bearing subsurface strata.

12. The **maximum pump load** is the maximum brake horsepower required to drive the pump. The pump manufacturer

determines this by shop test under expected suction and discharge conditions. Actual field conditions may vary from shop conditions.

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

14. A **disconnecting means** is a device, group of devices, or other means (such as a circuit breaker or disconnecting switches) whereby the conductors of a circuit can be disconnected from their source of supply.

15. The **fire pump branch circuit** is that part of the electric power circuit which supplies power to a fire pump motor only.

16. An **internal combustion engine** is 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.

17. A **diesel engine** is an internal combustion engine in which the fuel is ignited entirely by the heat resulting from the compression of the air supplied for combustion. Oil-diesel engines, which operate on fuel oil injected after compression is practically completed, are the type of diesel engine usually used as fire pump drivers.

18. A **spark-ignited engine** is an internal combustion engine in which the fuel-air mixture is ignited by an electric discharge from a spark plug.

19. **Electric motors** are classified according to mechanical protection and methods of cooling by NEMA Standards MG 1-1.20 and MG 1-1.21. Brief descriptions are as follows:

a. Open drip-proof electric motors meet the needs of most installations where operating conditions are relatively clean and dry.