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Standard for

the Installation of

CENTRIFUGAL FIRE PUMPS

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NATIONAL FIRE PROTECTION ASSOCIATION

International

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National Fire Protection Association

International

Executive Office: 60 Batterymarch St., Boston 10, Mass.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes two hundred national and regional societies and associations (list on outside back cover) and nearly eighteen thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

This is one of a large number of publications on fire safety issued by the Association; a complete list is available without charge on request. All NFPA standards adopted by the Association are published in the **National Fire Codes** which are re-issued annually. The standards, prepared by the technical committees of the NFPA and adopted in the annual meetings of the Association, are intended to prescribe reasonable measures for minimizing losses of life and property by fire. All interests concerned have opportunity through the Association to participate in the development of the standards and to secure impartial consideration of matters affecting them. Complete information on Committees will be found in the NFPA Year Book.

Official NFPA Definitions

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations, or that which is advised but not required.

APPROVED refers to approval by the authority having jurisdiction.

Units of measurements used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters. One foot = 0.3048 meters. One inch = 24.50 millimeters. One pound per square inch = 0.06805 atmospheres = 2.307 feet of water.

Approved Equipment

The National Fire Protection Association does not "approve" individual items of fire protection equipment, materials or services. The suitability of devices and materials for installation under these standards is indicated by the listings of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada, the Factory Mutual Laboratories and the American Gas Association (gas devices) test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

Centrifugal Fire Pumps.

NFPA No. 20 — 1960

This edition of the Standard for the Installation of Centrifugal Fire Pumps incorporates amendments and editorial revisions adopted by the NFPA Annual Meeting on May 20, 1960. A history of NFPA No. 20 and summary of the 1960 revisions are given on pages 107 and 108.

The present edition of these standards is the latest in the series of editions which have been issued periodically since the subject of centrifugal fire pumps was first referred to the NFPA Committee on Fire Pumps in 1904.

Standard for the Installation of

Centrifugal Fire Pumps

NFPA No. 20

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STANDARD FOR THE INSTALLATION OF CENTRIFUGAL FIRE PUMPS.

NFPA No. 20 — 1960

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. Charts showing head-delivery, efficiency and brake horsepower curves 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. SIZES OF PUMPS.

a. STANDARD SIZES — Standard sizes of fire pumps are 500, 750, 1,000, 1,500, 2,000 and 2,500 gpm. Larger sizes may be used in specially engineered applications.

b. SPECIAL SIZES — Special fire service pump sizes are 200, 300 and 450 gpm.

32. TYPES OF PUMPS.

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

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

c. SPECIAL FIRE SERVICE PUMPS — Pumps rated at 200, 300 or 450 gpm limited to 130 per cent capacity maxi-

mum, and for various pressures. The maximum power required shall not exceed the limitations of a 30-horsepower electric motor.

d. PRESSURE MAINTENANCE PUMPS (JOCKEY OR MAKE-UP PUMPS) — Under some circumstances it is desirable to maintain a uniform or a relatively high pressure on a fire protection system by the use of an automatic pressure maintenance pump. The size, operating pressure and type of pump shall be as approved by the authority having jurisdiction. In the majority of cases a commercial pump having a capacity of 20 to 50 gpm and suitable characteristics will be satisfactory. With the use of a turbine vane type of pump or of a displacement type of pump, a suitable relief valve shall be installed on the pump discharge.

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).

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. Where internal combustion engines are used for driving fire pumps, advantage should be taken, if possible, of the benefits to be secured from maintaining the engine block at 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. See Article 676.

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.

Size of Pump, gallons	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 150 pounds, relief valves may be required by the authority having jurisdiction. For pumps supplying standpipe systems only, relief valves will not generally be needed.

b. The relief valve should ordinarily be set to open at a pressure slightly in excess of the pressure at which the pump will usually be expected to operate; its capacity should be such that when so set it can pass all of the water discharged by the pump without developing excessive pressure.

c. 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. The cone should be piped to a point where water can be freely wasted, preferably outside the building.

d. 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.

e. 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.

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

Size of Pump, gpm.	500	750	1000	1500	2000-2500
Size of Relief Valve, inches	3	3½	4	5	6

g. 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.

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

h. 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.

Size of Pump, gallons	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 lbs. 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. 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. 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.

Size of Pump gpm	Size of Discharge Pipe See 42(a)	Size of Relief Valve See 43(f)	Size of Relief Waste See 43(g)	Number Hose Valves See 44(b)
500	6 in.	3 in.	5 in.	2
750	8 in.	3½ in.	6 in.	3
1000	8 in.	4 in.	8 in.	4
1500	10 in.	5 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, consideration should be given to the use of a vertical shaft turbine type pump 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, consideration should be given to the use of a vertical shaft turbine type pump.

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.

SIZE 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 size 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. Note auxiliary exhaust connection on pump casing in Fig. 100b (Appendix C).

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:

Size 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 456.
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 ½-inch float operated air release or equivalent valve to automatically release air from the pump.

133. TEST VALVES.

a. Pumps taking suction under lift shall be equipped with straightway 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.

Size of Pump, gallons	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.

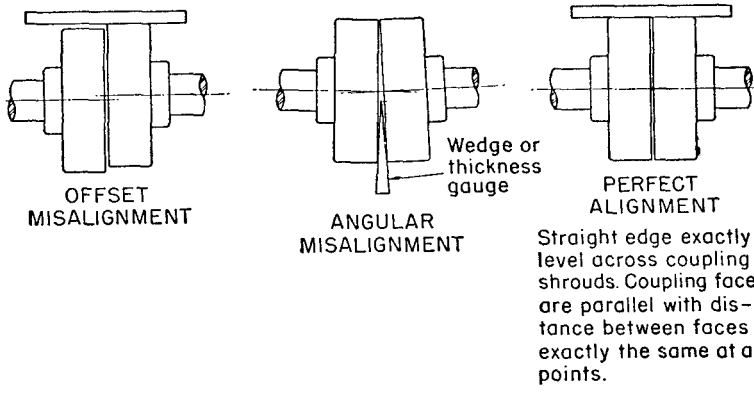

Fig. 142. Proper and Improper Shaft Alignment.

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. Use bell and spigot cast iron pipe with calked lead joints or standardized mechanical joint pipe. 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 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 in 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. gate valve in the suction pipe if the pump is ever supplied under a head.

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.

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 be greater than 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.

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 bottom 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 pump bowls should be 10 feet below the pumping water level at 150 per cent of normal capacity.

223. WELL CONSTRUCTION.

a. It shall be the ground water supply contractor's responsibility to make one or more test holes 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.

c. All casings shall be heavy wrought steel of such diameter and installed to such depths as the formation encountered may justify and in the contractor's opinion best meet the conditions.

d. Outer casing shall extend down to approximately the top of the water bearing formation. The inner casing of lesser diameter and 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.

e. The bottom of the well and sides of casing should be properly sealed to prevent foreign material entering.

f. The immediate area surrounding the 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 the water leaving the water bearing formation and entering the well.

g. Paragraphs (c) through (f) have reference to wells completed in unconsolidated geological 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.

224. DEVELOPING A WELL.

a. Developing a new well and freeing it from 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 actually gets into service.

b. Before the permanent pump is ordered, the water in the well should be analyzed for corrosiveness including such items as pH and harmful gases such as carbon dioxide (CO_2), hydrogen sulfide (H_2S), or chlorine (Cl_2). 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.

225. PRELIMINARY TEST AND INSPECTION OF WELL.

a. The preliminary test to obtain measurement of the water production shall be made through standard orifice

type measuring devices and witnessed by a representative of 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 rating with averaged hourly readings over the test period. All wells in the vicinity should be simultaneously in operation.

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. If it is found after a well has been drilled and cased, it is crooked, the water supply is doubtful, the water level has dropped, or the water contains considerable sand, gravel or gas, the authority having jurisdiction should again be consulted before proceeding with the pump installation.

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).
Blind flange.
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 (pounds pressure $\times$ 2.31 = feet) from the known length of the air line will give the amount of submergence.

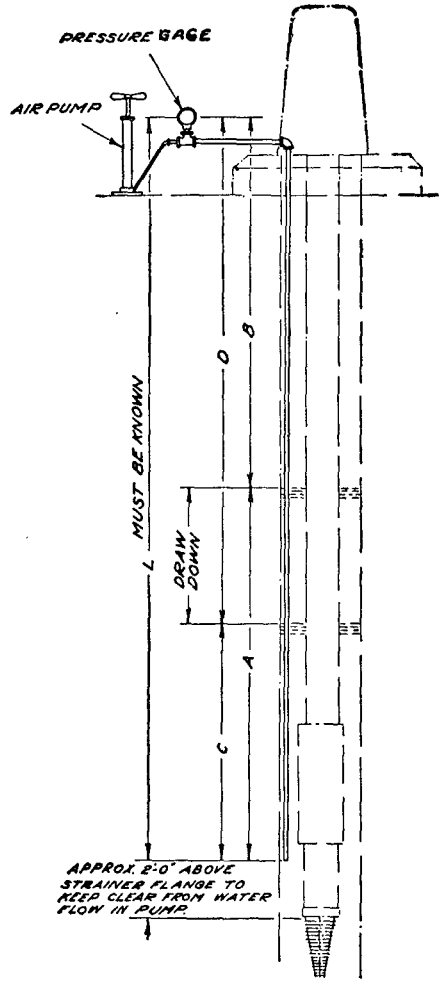

Fig. 236. Air Line Method of Determining Depth of Water Level.

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 676 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 against dirt 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 with internal combustion engine or steam turbine. The speed of the pump should not exceed 1,800 rpm under any conditions. 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, suitable for full voltage starting and having locked rotor current not exceeding the values given in the table in Paragraph 451c. The motor shall be designed for a temperature rise not exceeding 40°C and be of such a capacity that at rated voltage, 115 per cent of its full load ampere rating will not be exceeded under any condition of pump operation. The pump manufacturer shall be responsible for a motor of ample size to drive the unit under any pump load. 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.

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 an approved free wheeling clutch.

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 for eight hours with discharge at 150 per cent rated capacity at 65 per cent of the total rated head.

b. A yearly inspection and test at 150 per cent rating to determine pumping 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 SIZES. The standard sizes of special fire service pumps have nominal capacities of 200, 300 and 450 gallons per minute with pressure boosts ranging from 40 to 100 pounds per square inch. 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 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. The casing shall be designed to withstand hydrostatic pressure of at least 250 pounds per square inch.

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. A ¾-inch air release valve, and a ¾-inch pressure relief valve set slightly below the shut-off pressure, are recommended.

350. Driver.

351. CAPACITY. Motors shall be of such capacity that at rated voltage (and for a-c motors at rated frequency) their full load ampere rating will not be exceeded 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.

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, 455, 457, 458.

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. 322 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 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 by the load carried.

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.

433. OVERCURRENT PROTECTIVE DEVICES. Overcurrent protective devices (fuses or circuit breakers) installed in

the power supply circuits at utility plants, or substations ahead of the plant distribution circuit breakers, shall be rated and in the case of circuit breakers set so as not to open these circuits under stalled rotor current or other motor starting conditions at the fire pump motor under maximum plant load. Fuses are not recommended in the fire pump motor feeder circuit at plant bus. Overcurrent protective devices installed in the fire pump motor or feeder circuit should have overcurrent setting for short circuit protection only.

NOTE: Each ungrounded conductor should be protected. See Article 522 regarding overcurrent protection for the motor branch circuit conductors.

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. Electric motors are an accepted dependable source of power for operation of centrifugal fire pumps. It is the pump manufacturer's responsibility to provide a motor of ample size as specified in Section 453. Only motors wound for 208 volts shall be used for 208 volt services. 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. 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.) 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 at 220 volts not exceed the following values:

Rated Horsepower	*Locked-Rotor Current Three Phase, 220 Volts*	*NEC Letter*
5	90	H
7½	120	G
10	150	G
15	220	F
20	290	F
25	365	F
30	435	F
40	580	F
50	725	F
60	870	F
75	1085	F
100	1450	F
125	1815	F
150	2170	F
200	2900	F

NOTE: In the foregoing table, the locked-rotor currents are given at 220 volts; they are approximately 6 times the full load current. Locked-rotor current of motors designed for other voltages will be inversely proportional to the voltage. (For example, a 15 horsepower-440 volt motor would have a value of 110 amperes.)

452. VOLTAGE LIMITS. 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. Open motors and drip-proof motors shall be of such capacity that at rated voltage (and on a-c motors at rated frequency) 115 per cent of their full load ampere rating will not be exceeded under any conditions of pump load.

b. Splash-proof and totally-enclosed fan-cooled 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 under any conditions of pump load.

454. TEMPERATURE LIMITS. With a room temperature not exceeding 40° C (104° F), open motors and drip-proof motors shall be designed for a temperature rise not exceeding 40° C when carrying their rated full load continuously and shall also be able to run continuously with an overload of 15 per cent without stress and without injurious rise in temperature. With a room temperature of 40° C, splash-proof motors shall be designed for a temperature rise not exceeding 50° C and totally-enclosed fan-cooled motors shall be designed for a temperature rise not exceeding 55° C when carrying rated load continuously. The rise in temperature shall be measured in accordance with the current American Standard C50 for Rotating Electrical Machinery.

455. 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 — 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.
Temperature rise — rpm at full load.
Frequency.
Number of phases.
Voltage.
Full load amperes.
Code letter.

Wound Rotor Induction Motor —

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

456. 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. Motors of the totally-enclosed fan-cooled or splash-proof type shall be acceptable without splash partition, described above, providing they have ventilating inlet and discharge located as to prevent entrance of dripping or splashing water. This also applies to drip-proof motors when the hose valves are located outside the pump room.

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

457. 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.

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

Chapter 500.

ELECTRIC DRIVE CONTROLLERS.

510. General Requirements for All Controllers.

511. GENERAL.

a. Motor control equipment shall be completely assembled, wired and tested at the factory before shipment, and the assembly shall be specifically approved for fire pump purposes. All equipment shall be suitable for use in a damp location, that is it shall be of a type such that reliability of operation will not be adversely affected by installation in a location subject to a moderate degree of moisture, as some basements.

b. 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. High voltage controllers shall be limited to the automatic type, and rated at not more than 4,160 volts. (See Article 540.)

512. THE UNIT.

a. MOUNTING. The motor control equipment, circuit-breaker, and isolating switch shall be mounted in a substantial manner on a single noncombustible supporting structure.

b. MARKING. Motor control equipment conforming to this standard shall be marked "Fire Pump Controller." Each motor control equipment and each switch and circuit breaker shall be marked to indicate plainly the name of the manufacturer and his designated catalog number or equivalent designation, 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.

c. ENCLOSURE. All equipment shall be in one or more approved enclosures which will protect the equipment against mechanical injury and be drip tight. The equipment shall be so located or protected that it will not be injured by water escaping from the pump or connections. The controller enclosure shall be provided with a bull's-eye directly in front of the pilot lamp (see Section 524).

d. 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 521.

513. CONNECTIONS.

a. BUS BARS AND CONNECTIONS. All bus bars and connections shall be readily accessible for maintenance work after installation of the enclosure, without disconnecting the external circuit conductors.

b. TEST CONNECTIONS. Provision shall be made to allow the use of test meters by one of the methods outlined in the following paragraphs (1) or (2).

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

2. There shall be provided as a part of the complete control equipment, 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 somewhere between the isolating switch and the controller.

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

515. LOCATION.

a. The control devices or panel shall be located close to and within sight of the motor.

b. A clearance of not less than 2½ feet should be provided at the rear of panels designed to be inspected and serviced from the rear.

c. If a pump room is provided and used for no other purposes, the controlling equipment shall be placed in this room.

516. AUXILIARY FEATURES.

a. POWER AVAILABILITY SIGNAL. In some locations an audible or visual alarm, or both, may be required by the authority having jurisdiction to indicate when either the circuit breaker, isolating switch or test link is open. This may be accomplished through use of a drop-out type of relay controlling an alarm circuit energized by a reliable source of power supply. The relay should be heavy duty type which will close on failure of voltage. The alarm devices should be located at a point of constant attendance.

b. 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.

c. OPERATING ALARM. When an automatic pump is located in a detached building or away from the supervising engineer, the authority having jurisdiction may require the controller to be equipped with a contact which will close when the pump starts thereby energizing a circuit not to exceed 125 volts to operate an audible or visual alarm at a point of constant attendance indicating that the pump is in operation.

520. Non-automatic Type—600 Volts or Less.

521. ISOLATING SWITCH.

a. 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. It shall be outside operated 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. The ampere rating of the switch shall be at least 115 per cent of the nameplate current rating of the motor.

b. 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 SWITCH) IS IN CLOSED POSITION."

522. CIRCUIT BREAKER (Disconnecting Switch).

a. The motor branch circuit on the load side of the isolating switch shall be protected by means of an externally operable circuit breaker with one pole in each conductor, and having a rating of at least 115 per cent of the rated full-load current of the motor. The circuit breaker shall permit normal starting of the motor without tripping and shall provide stalled rotor and instantaneous short-circuit protection. On the outside of the enclosure and adjacent to the means for tripping the circuit breaker, there shall be a nameplate with the legend "CIRCUIT BREAKER — DISCONNECTING MEANS" with letters not less than 3/8" high.

b. For a squirrel cage induction motor it shall be of the time-delay type and have a time-delay of not over 20 seconds on 600 per cent (locked rotor current) of the motor full load current; a magnetic type circuit breaker shall be calibrated at least up to and set at 300 per cent of the motor full load current.

c. For a direct-current motor and a 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.

d. The interrupting rating of the circuit breaker shall be adequate for the circuit in which it is to be used and shall be not less than 15,000 amperes in any case. The circuit breaker interrupting capacity required should be obtained by the purchaser based on maximum possible short circuit current at the pump room.

e. The circuit breaker shall be connected in the circuit directly on the load side of the isolating switch. No other over-current protection devices shall be in the motor circuit on the load side of this circuit breaker. It shall trip free from the handle.

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

523. MOTOR STARTER.

a. OPERATING MEANS. The motor starter shall be equipped with a handle or lever which operates to close the motor-circuit switching mechanism mechanically with-

TABLE 522.

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

(See Section 522 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: No branch Cir. Br. (See Fig. 430 A-1 and A-2)	I.C. of Cir. Br. of Fire Pump Controller — Amperes: With branch Cir. Br. (See Fig. 430 A-3 and A-4)
FIRE PUMP MOTORS OF 75 HP. OR LESS				
750	240	50-75	25000	15000
750	240	Over 75	15000	15000
1000	240	50-85	25000	15000
1000	240	Over 85	15000	15000
1500	480	50-75	25000	15000
1500	480	Over 75	15000	15000
1500	240	50-100	25000	15000
1500	240	Over 100	15000	15000
2000	600	25-65	25000	15000
2000	600	Over 65	15000	15000
2000	480	50-85	25000	15000
2000	480	Over 85	15000	15000
2000	240	20-54	50000	25000
2000	240	55-105	25000	15000
2000	240	Over 105	15000	15000
FIRE PUMP MOTORS OF 100 HP. AND 125 HP.				
1000	240	50-110	25000	15000
1000	240	Over 110	15000	15000
1500	480	50-110	25000	15000
1500	480	Over 110	15000	15000
1500	240	25-65	50000	25000
1500	240	66-125	25000	15000
1500	240	Over 125	15000	15000
2000	600	20-55	50000	25000
2000	600	56-135	25000	15000
2000	600	Over 135	15000	15000
2000	480	20-60	50000	25000
2000	480	61-135	25000	15000
2000	480	Over 135	15000	15000
2000	240	30-80	50000	25000
2000	240	81-140	25000	15000
2000	240	Over 140	15000	15000

out dependence upon any electric control circuits or magnets (or equivalent devices). Except for an auto-transformer reduced-voltage type starter, the lever shall be arranged to move in one direction only from the initial to the final position.

b. 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.

c. In addition, the motor starter shall have means for electrical operation for starting and stopping the motor, except that an auto-transformer reduced-voltage type of starter need not have electrical control means for starting the motor.

d. ADDITIONAL CONTROL STATIONS. Additional control stations for initiating the electrical operating means for starting the motor may be provided at locations remote from the controller, but such stations shall not be operable to stop the motor.

524. PILOT LAMP. A standard 115-125 volt 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. 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 shall be used to reduce the voltage to that required for operating the lamp. The lamp shall be readily accessible for replacement.

525. CONTROLLER WIRING. Bus bars and other wiring elements of the motor 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.

530. Automatic Type—600 Volts and Less.

531. GENERAL

a. Control equipment of the automatic type shall comply with the general requirements for all controllers (Article 510) and with those for non-automatic type (Article 520) and, in addition, shall comply with the provisions of the following Sections 532 and 533.

b. PROVISION FOR TESTING. Provision shall be made in the pressure system for relieving the pressure on the pressure switch to test the automatic operation of the controller and pump motor (Fig. 531, Appendix C).

532. MOTOR STARTER.

a. AUTOMATIC ACCELERATION. Except for full-voltage type motor starters, definite-time automatic acceleration of the motor shall be provided, and the period of motor acceleration shall not exceed 10 seconds.

b. AUTOMATIC OPERATION. Actuation of the motor starter for starting the motor automatically shall be under the control of an acceptable type pressure switch having independent high and low calibrated adjustments in the control circuit, which is responsive to water pressure in the fire system. The pressure control may be either one or both of the following two types: (1) Continuous running after automatically started until stopped by manual operation of the circuit breaker, or (2) automatically stopped when a pre-determined high pressure is reached in the fire system and after the motor has run for the time fixed by the running period timer. With type (2) control, too frequent automatic starting of the motor shall be avoided by providing an automatic instantaneous recycling running period timer that will keep the motor in operation for one minute for each ten horsepower motor rating, but not to exceed 7 minutes.

c. Controllers for multiple pump units shall incorporate a sequential timing device to start the units at five-second intervals.

d. For sprinkler systems and standpipe systems, where an automatically controlled pump constitutes the sole supply, or where required by the authority having jurisdiction, there shall be automatic means for keeping the pump continuously in operation in case of a normal demand for water, such as the discharge of one or more sprinklers or hose streams.

e. NON-AUTOMATIC OPERATION. Provision shall be made in the controller for non-automatic continuous operation of the motor independent of the pressure-actuated control switch, and for returning the controller to automatic operation. The controller shall be equipped with a handle or lever which operates to close the motor-circuit switch-

ing mechanism mechanically for non-automatic continuously-running operation of the motor, as in the case of the non-automatic controller (Paragraph 523a), independent of the pressure-actuated control switch.

f. ADDITIONAL CONTROL STATIONS. Additional control stations for causing non-automatic continuous operation of the motor 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 motor.

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

540. Automatic Type — In Excess of 600 Volts.

541. CONTROL EQUIPMENT. Where equipment rated in excess of 600 volts is permissible (See Section 511) the control equipment shall comply with the requirements of Sections 531 and 532 except as indicated in Sections 542-548.

542. PROVISIONS FOR TESTING. The provisions of Paragraph 513b 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.

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

544. LOCATION OF PRESSURE ACTUATED SWITCH. Special precautions should be taken with regard to the location of the pressure-actuated switch called for in Paragraph 532b to prevent any water which may be present due to leakage from coming in contact with high-voltage components.

545. 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 voltage shall be interrupted when the main disconnecting means is in the open position.

546. PILOT LAMP. For these controllers Section 524 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.

547. 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.

548. 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.

550. Automatic Controllers for Auxiliary Booster and Special Fire Service Pumps.

551. BASIC DATA.

a. APPLICATION. This section is applicable to automatic controllers for across-the-line type squirrel cage motors of 30 horsepower or less, 600 volts or less, used as booster pumps or as special fire service pumps, where such use is acceptable to the authority having jurisdiction. These controllers are not intended as a substitute for standard fire pump controllers.

b. GENERAL. Motor control equipment shall be completely assembled, wired and tested at the factory before shipment, and the assembly shall be specifically approved for auxiliary booster and special fire service pumps. All equipment shall be suitable for use in a damp location, that is, it shall be of a type such that reliability of operation will not be adversely affected by installation in a location subject to a moderate degree of moisture, as some basements.

552. THE UNIT.

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

b. MARKING. Each motor control panel shall be marked "Controller for Auxiliary Booster or Special Fire Service Pump" and marked to indicate plainly the name of the manufacturer and his designated catalogue number or equivalent designation, and the electrical rating in volts, horsepower, frequency, phase, etc., as may be appropriate. These markings shall be so located as to be visible after installation.

c. ENCLOSURE. All equipment shall be completely enclosed to provide protection from mechanical injury and the enclosure shall be drip tight. The equipment shall be so located or protected that it will not be injured by water escaping from the pump or connections. The controller enclosure shall be provided with a pilot light bull's-eye to indicate that power is available at the controller.

d. 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).

e. CONDUCTORS AND CONNECTIONS. All conductors and connections shall be readily accessible for maintenance work after installation of the enclosure.

553. PROTECTION OF AUXILIARY CIRCUITS. Auxiliary circuits required by this motor control shall not have overcurrent protective devices connected in them.

554. LOCATION. The controller shall be located close to and within sight of the motor. If a pump room is provided and used for no other purposes, the controller shall be placed in this room.

555. CIRCUIT BREAKER.

a. An automatic circuit breaker, having one pole for each ungrounded conductor shall be provided to disconnect automatically and to isolate the motor and controller from the line, in the event of a short circuit. This circuit breaker shall be approved for disconnect purposes and no further disconnecting device will be required on the control panel. The circuit breaker shall have a continuous rating of at least 115 per cent of the motor full-load current and shall have a current interrupting capacity adequate for the cir-

cuit in which it is to be used and not less than 10,000 amperes.

b. The circuit breaker shall be of an approved type and size which will allow repeated starting at the intervals permitted by the running period timer without tripping, and provide instantaneous short circuit protection. 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. The circuit breaker shall trip free of the handle and the calibration shall be of the fixed type to discourage adjusting and tampering by unauthorized persons.

c. No other over-current protection device shall be in the motor circuit on the load side of the circuit breaker.

556. MOTOR STARTER. The motor starter shall be of the heavy duty magnetic type with contact in each conductor.

a. AUTOMATIC OPERATION. Actuation of the motor starter for starting the motor automatically shall be under the control of an acceptable type pressure switch having independent high and low calibrated adjustments in the control circuit, which is responsive to water pressure in the fire system. The pressure control may be either one or both of the following two types—(1) Continuous running after automatically started until stopped by manual operation of the circuit breaker, or (2) automatically stopped when a pre-determined high pressure is reached in the fire system and after the motor has run for the time fixed by the running period timer. With type (2) control, too frequent automatic starting of the motor shall be avoided by providing an automatic instantaneous recycling running period timer that will keep the motor in operation for one minute for each ten horsepower motor rating.

b. NON-AUTOMATIC OPERATION. Provision shall be made in the controller for non-automatic continuous operation of the motor independent of the pressure actuated control switch and for returning the controller to automatic operation.

c. MANUAL SELECTOR STATION AT CONTROLLER. A two-position station shall be provided on the control enclosure with the pilot switch marked "Automatic" and "Nonautomatic" with no stop or off position.

557. LOCAL SUPERVISION.

a. A pilot light shall be provided on the line side of the motor starter (load side of breaker) to indicate that power is available at the controller.

b. An alarm relay, normally open, shall be connected on the line side of the motor starter (load side of the breaker) that will drop closed on voltage failure or if the circuit breaker is open. (Alarm device to be energized by some other reliable independent source of power.)

c. Means shall be provided on the controller to operate an alarm signal continuously while the pump is running.

558. CONTROLLER WIRING. Conductors and other wiring elements of the motor controller shall be designed on a continuous duty basis.

Chapter 600.
INTERNAL COMBUSTION ENGINE DRIVE.

610. General.

611. RECOMMENDED USE. Fire pump equipments of the internal combustion engine type are advised only as supplemental units or where other sources of power are not dependable or not available. See Chapter 700 — Combined Manual and Automatic Controllers for Internal Combustion Engines Driving Centrifugal Fire Pumps.

620. Engines.

621. APPROVAL. Engines shall be specially 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. 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.

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

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.

623. CONNECTION TO PUMP.

a. Except where otherwise permitted by the authority having jurisdiction the engine shall be directly connected to the pump by means of a flexible coupling of suitable design, without gears or belting.

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.

624. INSTRUMENTATION AND CONTROL.

a. GOVERNOR. A governor shall be provided for the engine to regulate the speed within a range of 10 per cent between shut off and maximum load conditions of the pump. It shall be set to maintain rated speed at rated load.

b. 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.

c. OIL PRESSURE GAGE. An oil pressure gage shall be provided to indicate engine lubricating oil pressure and a temperature indicator to indicate engine cooling water temperature.

d. 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.

625. STORAGE BATTERY.

a. GENERAL. A storage battery of ample size for starting the engine, providing energy for engine control devices on automatic installations, and to provide current for electric ignition systems shall be of ample size for the service required and shall be carefully selected and maintained. A high tension magneto of suitable type may be used as a secondary source of ignition. The battery shall be of premium quality double insulated heavy duty truck or bus type, properly selected and applied by the pump manufacturer. Batteries shall be furnished in a dry charge condition with electrolyte liquid in a separate container. Electrolyte should be added at the time the unit is put in service.

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

c. SERVICE. The battery in an engine-driven installation is a very critical item and should be very carefully

serviced and immediately replaced when hydrometer readings indicate that it is weakening.

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. The charger shall have the following basic design features for dependable service:

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

2. The rectifier shall be of the semi-conductor type, e.g., copper oxide, germanium, selenium and silicon.

3. The charger shall be of the on-off type which is accurately controlled by a temperature compensated voltage sensitive relay.

4. The charger 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.

5. 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.

6. The control equipment incorporated in the charger shall start the rectifier hourly and automatically shut off when the battery has been fully charged.

7. An ammeter of an accuracy of 2 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.

f. 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.

g. LOCATION. Storage batteries shall be substantially supported, secured against displacement, and located where they will not be subject to excessive heating, mechanical injury or flooding with water. Location at the side of and on a level with the engine is suggested.

626. STARTING DEVICES.

a. Gasoline engines shall be equipped with an electric starting device taking current from the storage battery. Diesel engines should preferably be so equipped 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.

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. The pipe connection shall include a manual flow regulating valve, a strainer, and a manual shut-off valve. A pressure regulating valve shall be added at the outlet of the strainer when required to protect the heat exchanger or other low pressure parts against high pressure in the system. 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 strainer or pressure regulating valve and strainer.

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 discharge water from the engine jacket.

628. CARBURATION.

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 gasoline engines with a displacement of 350 cubic inches and larger to insure positive shut down without dieseling. Control for the device shall be provided by the automatic engine controller or supplemental accessories to the controller 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. 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 and that complete means of drainage and ventilation be provided. Ventilation should be adequate for engine air supply and for removal of hazardous vapors.

632. VENTILATION. 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. Means for thorough ventilation shall be provided.

640. Gasoline Supply.

641. CAPACITY. 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. For a 1,000 gallon pump this would mean about 100 gallons minimum capacity.

642. LOCATION. 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. Fuel pump suction lines shall be copper tubing at least $\frac{3}{8}$ inch in size. 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.

643. FEED. The gasoline shall be fed to the carburetor by that method which will be most dependable and safe. Of the several methods available for this service there are two which are acceptable. One is the gravity system with a service tank of one-half hour's supply and a hand pump, and the other is a pumping system involving a pump driven from the engine with a service tank of about two quarts capacity.

644. REVIEW OF PLAN. Before either of these two systems is installed the authority having jurisdiction should be consulted as to the system proposed to the end that the suitability of the system for the conditions be determined.

645. FLEXIBLE CONNECTION. A suitable flexible connection shall be provided in the fuel line where it connects to the engine.

650. Fuel Supply Arrangement.

651. FOR GASOLINE ENGINES. This system uses 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. 651 in the Appendix for a suggested arrangement. This may be modified to suit the conditions, subject to approval by the authority having jurisdiction.

652. FOR DIESEL ENGINES.

a. The capacity of the main oil 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. The tank shall be located in accordance with municipal ordinances and requirements of authority having jurisdiction. Means shall be provided for determining the

amount of oil in the storage tank. The tank should have suitable filling and vent connections. No shut-off valve shall be installed in the fuel return line to the tank. See Figure 652 in the Appendix for a suggested arrangement.

NOTE: Allow one-half pound of oil per horsepower per hour. For a 1,000-gallon pump this would mean about 75 gallons minimum capacity.

b. The location, construction and installation of tanks and vents, piping, oil gaging, oil pumps, valves, pre-heating and maintenance shall be in accordance with the Standard for the Installation of Oil Burning Equipments (NFPA No. 31).

660. Fuel and Exhaust Piping.

661. GASOLINE PIPING. All gasoline piping between tanks and between tanks and engines shall be approved seamless copper tubing with flared joints or brass pipe with soldered screwed joints. Flexible connections shall be of approved metallic type.

662. GUARDS. There shall be provided a guard or protecting pipe at all pipes exposed above the floor.

663. EXHAUST PIPING. Exhaust from the engine shall be piped to a safe point outside the pump room and arranged to exclude water. A flexible connection should be made between the exhaust manifold 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.

670. Maintenance.

671. 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 cov-

ering care and operation should be preserved and pump operators should be familiar with its contents and should observe in detail all of its provisions.

672. WEEKLY RUN. The engine and pump shall be started at least once a week and run sufficiently long to bring the engine up to normal running temperature and to make sure that the pump has water and pressure is raised and that the engine and pump are running smoothly at rated speed.

673. 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.

674. ENGINE UPKEEP. The engine should be kept clean and dry and well lubricated.

675. 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.

676. TEMPERATURE.

a. 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.

b. Manually started engines may be installed in pump rooms where ambient temperatures may at times fall below these values, though in no case should they be allowed to go below 40° F.

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

d. Since fire pump engines must carry full load as soon as possible after starting, it is suggested an automatic immersion heater be employed to maintain jacket water temperatures of liquid cooled engines at a minimum of 120° F when ambient temperatures below 60° F occur.

677. OIL. Plenty of oil shall be maintained in the crank case and new oil substituted when it has become fouled or appreciably changed in viscosity.

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

Chapter 700.

COMBINED MANUAL AND AUTOMATIC CONTROLLERS FOR INTERNAL COMBUSTION ENGINE DRIVE.

710. General.

711. APPLICATION.

a. The following specifications cover controlling equipment of the combined manual and automatic type for internal combustion engines driving centrifugal fire pumps. The preceding sections dealing with gasoline or diesel engines driving fire pumps also apply insofar as they are appropriate.

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

712. APPROVAL. All controllers shall be specifically approved for fire pump service.

713. TESTING. The control panel shall be fitted up completely and properly tested by the manufacturer before shipment from the factory.

NOTE: Automatically started internal combustion engine driven fire pumps are usually installed as a secondary source of water supply for fire protection, to supplement primary supplies from public water systems, gravity tanks or other reliable sources.

720. Mounting.

721. PANEL. There shall be provided a structure or panel of noncombustible material on which is mounted all the control equipment for automatic operation, but not including the manual equipment covered by Paragraph 624d.

722. ENCLOSURE. The structure or panel shall be securely mounted, in a dust-proof and moisture-proof enclosure.

730. Equipment.

731. AUTOMATIC CONTROL.

a. Automatic control shall be such as to maintain the system pressure through the action of some suitable device, such as a pressure switch, and shall be so arranged that when the pumping unit is once started it will remain in operation for a period of at least 30 minutes.

b. To assure dependable starting of the pumping unit, the controlling equipment shall be arranged to automatically start the pumping unit at least once a week and operate for at least 30 minutes. Such performance shall be automatically indicated on a recording pressure gage.

732. MANUAL CONTROL.

a. In addition to the automatic operation described in the foregoing, there shall be a manually-operated switch in the control panel.

b. The equipment shall be so arranged that when the pumping unit is started manually, its operation can not be affected by the pressure switch and so that the unit will remain in operation until manually shut off.

733. SIGNALS. Signals as indicated in the following shall be provided for:

a. A pilot lamp connected in the starting motor circuit indicating the presence of voltage on the line.

b. A bell and pilot lamps to indicate low oil pressure in the oiling system, high engine jacket water temperature, and failure of the engine to start automatically.

734. TEST DEVICE. Suitable provision shall be made for relieving pressure to the pressure switch to test the operation of the controller and the pump (Fig. 531, Appendix C).

735. LOCKS. All control switches shall be within locked cabinets having break-glass panels.

736. COOLING CONTROL. An electric Solenoid valve shall be installed in place of the manual shut-off valve in the raw water piping between the fire pump and the engine cooling system previously described in Section 627.

737. STARTING.

a. Two storage batteries shall be provided and so arranged that manual and automatic starting of the equipment can be accomplished with either. The starting current shall be furnished by first one battery and then the other on successive operations of the starter, the change-over to be made automatically. The connection from the charging generator on the engine shall likewise alternate from one battery to the other. In addition, an automatically controlled charger conforming to Paragraph 625e shall be provided.

b. A suitable automatic choke shall be provided on a gasoline engine to facilitate starting.

738. ANTI-DIESELING DEVICES. Provisions for use of anti-dieseling devices shall be included.

740. Wiring.

741. PERMANENT DIAGRAM. A wiring diagram shall be provided and permanently attached to the control panel.

742. SIZE AND PROTECTION. All wiring leading from the panel to the engine and battery shall have adequate carrying capacity and shall be protected against mechanical injury.

750. Marking.

751. OF CONTROLLER. All controllers shall be marked to show plainly the name of the manufacturer, the model designation, the shop number and the electrical rating in volts.

752. OF WIRING. All terminals shall be plainly marked to correspond with the wiring diagram furnished.

760. Location.

761. GENERAL. The control panel shall be located as close to the engine as is practicable and shall be so located or protected as to minimize the danger of damage from water escaping from the pump or connections. A clearance of not less than 2 feet should be provided at the rear of panels to be inspected and serviced from the rear.

770. Installation.

771. INITIAL. It is recognized that the installation and adjustment of this equipment require the services of a representative of the manufacturer.

780. Maintenance.

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

790. Auxiliary Features.

791. GENERAL. Auxiliary features similar to those covered by Section 516 and Paragraph 532f may be required by the authority having jurisdiction.

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. The turbine and pump shall be assembled completely in the shop of the pump manufacturer.

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.

814. SPEED. The rated speed should not exceed 3500 rpm.

NOTE: Low speed turbines (1750 rpm) are less efficient but are sometimes justified for dual drive in connection with an electric motor.

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 which should be capable of maintaining, at all loads, the rated speed within a total range of approximately 8 per cent 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 per cent 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 turbine is running to secure speeds approximately 5 per cent above and 5 per cent below the rated speed.

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 rated speed.

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. In lieu of a quick opening valve a satisfactory, pilot type, diaphragm valve in the steam feeder by-pass around the manual control valve will be acceptable.

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.

828. BED PLATE. The pump and steam turbine must be connected together as one substantial unit, either by a cast-iron bed plate or other approved means.

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.

NOTE: 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.

912. OVERHEATING.

a. As installed, the pump shall be able to discharge its rated capacity at its rated net head without objectionable heating of bearings or of prime mover.

b. At rated speed, pump shall be able to discharge not less than 150 per cent of its rated capacity at a total head not less than 65 per cent of the total rated head and without objectionable heating of bearings or of prime mover.

913. SHUT-OFF TOTAL HEAD. With all discharge outlets (including relief valves) closed, the shut-off total head for horizontal shaft pumps should not exceed 120 per cent of total rated pressure. The shut-off pressure for vertical shaft pumps shall not exceed 140 per cent of rated pressure.

914. SPEED. If provision is made for varying the speed of the prime mover, it shall be operated at various speeds (from minimum to maximum) which would be likely in case of fire. Under all conditions the pump and prime mover shall run smoothly and the control equipment shall function properly.

915. OPERATING CONDITIONS.

a. By varying the number and/or size of the discharge outlets in connection with tests (Sections 912, 913, and 914) the operating conditions under minimum to peak loads shall be determined.

b. During such test:

1. Current to the electric motor shall not exceed rated full-load current for motors having a rated temperature rise of 50° C or 55° C, nor more than 115 per cent of the rated full load current for motors having a rated temperature rise of 40° C.

2. An internal combustion engine shall not show signs of overload or stress and its governor shall properly regulate the speed.

3. A steam turbine shall maintain its speed within 5 per cent of rated speed under governor control except that at pump loads in excess of rated capacity, auxiliary nozzles may be opened manually to bring turbine up to rated speed.

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 electric pumps shall be put through not less than ten complete operations.

b. Combined manual and automatic electric controllers shall be put through not less than ten automatic and ten manual operations. A running interval of at least five minutes at full speed should be allowed to permit cooling of the motor before repeating the starting cycle. Automatic operation of electric controllers shall start and stop pump at specified pressure limits and period of motor acceleration shall not exceed ten seconds. The repeated starting of internal combustion engine driven units should be made with at least 5 minutes interval between starts.

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.

920. Operating Instructions for Centrifugal Fire Pumps.

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-gallon 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 not objectionable. 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.

930. Care of Pump.

931. WEEKLY TEST. A centrifugal fire 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 bearings, suction pipe and strainers and the several details pertaining to the electrical equipment.

932. YEARLY TEST. A yearly test with fire hose 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.

APPENDIX B

GUIDE FOR DIAGNOSING DEFECTS

The chart lists pump troubles and their possible causes. Suggested remedies are covered in this article. The causes are in addition to possible mechanical breakage that would be obvious on visual inspection. When a pump does not deliver its rated head and quantity, those causes of trouble which can be checked easily should be corrected first or eliminated as possibilities.

Remedies for Causes of Pump Troubles.

1. **Suction lift too high** — should not exceed 15 feet for horizontal shaft pump. See Section 121. Measure vertical distance from pump center line to water level and if it, plus friction loss in suction pipe (Fig. 143a), is over 15 feet, rearrange suction supply. Check that suction connection is arranged according to Section 143.

2. **Foot valve too small or of inferior design causing excessive suction head loss** — Replace with approved foot valve of proper size. See Section 143.

3. **Air drawn into suction connection through foot valve not submerged enough** — Lower foot valve.

4. **Air drawn into suction connection through leak(s)** — Air drawn into suction line through leak causes a pump to lose suction or fail to maintain its discharge pressure. Uncover suction pipe and locate and repair leak(s).

5. **Suction connection obstructed** — Examine suction intake, screen, foot valve and suction pipe and remove obstruction. Repair or provide screens to prevent recurrence. See Section 143.

6. **Air pocket in suction pipe** — Air pockets cause a reduction in delivery and pressure similar to an obstructed pipe. Uncover suction pipe and rearrange to eliminate pocket. See Section 143.

7. **Hydraulic cavitation from too high suction lift** — See possible cause 1.

8. **Well collapsed or serious misalignment** — Consult a reliable well drilling company and the pump manufacturer regarding recommended repairs.

9. **Stuffing box too tight or packing improperly installed, worn, defective, too tight, or incorrect type** — Loosen gland swing bolts and remove stuffing box gland halves. Replace packing.

10. **Water-seal or pipe to seal obstructed** — Loosen gland swing bolt and remove stuffing box gland halves along with the water-seal ring and packing. Clean the water passage to and in the water-seal ring. Replace water-seal ring, packing gland and packing in accordance with manufacturer's instructions.

11. **Air leak into pump through stuffing boxes** — Same as possible cause 10.

12. **Impeller obstructed** — Does not show on any one instrument, but pressures fall off rapidly when an attempt is made to draw a large amount of water.

For horizontal shaft pumps: Remove upper case of pump and remove obstruction from impeller. Repair or provide screens on suction intake to prevent recurrence.

For vertical shaft pumps: Lift out column pipe (Fig. 200a and b, Appendix C) and pump bowls from wet pit or well and disassemble pump bowl to remove obstruction from impeller (Fig. 200a and b, Appendix C).

13. **Wearing rings worn** — Remove upper case and insert feeler gage between case wearing ring and impeller wearing ring. Clearance when new is .0075 inches. Clearances of more than .015 are excessive.

14. **Impeller damaged** — Make minor repairs or return to manufacturer for replacement. If defect not too serious, order new impeller and use damaged one until replacement arrives.

15. **Wrong diameter impeller** — Replace with impeller of proper diameter.

16. **Actual net head lower than rated** — Check impeller diameter and number and pump model number to make sure correct head curve is being used.