NFPA No. 20

Standards for the Installation and Operation of CENTRIFUGAL FIRE PUMPS

1951

*Fifty Cents**

NATIONAL FIRE PROTECTION ASSOCIATION
International
60 Batterymarch Street, Boston 10, Mass.

2M-6-51 W.A.S. Printed in U.S.A.

*Discount for quantities

National Fire Protection Association

INTERNATIONAL

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 over a hundred and seventy-five national and regional societies and associations and over thirteen thousand individuals, corporations, and organizations.

This pamphlet is one of a large number of publications issued by the Association. These include the monthly *Fire News*, *Quarterly* magazine, standards on fire prevention and fire protection, special reports and bulletins, the *Year Book*, and the *Proceedings* of the annual meetings.

Standards of the National Fire Protection Association, prepared by representative technical committees and adopted at the annual meetings of the Association, are intended to provide reasonable measures for saving life and minimizing losses from fire. All interests concerned have opportunity through the NFPA to participate in the development of standards and to secure impartial consideration of matters affecting them. NFPA standards are purely advisory as far as the Association is concerned but are widely used as guides to good practice, by fire department, building department and insurance inspectors and for regulatory purposes. A complete list of standards and informative and educational publications of the Association is available from the Executive Office without charge.

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Centrifugal Fire Pumps.

1951

(NFPA No. 20)

This edition of the Standards for the Installation and Operation of Centrifugal Fire Pumps incorporates amendments adopted by the National Fire Protection Association on May 11, 1951, on recommendation of the Committee on Fire Pumps. This edition supersedes that published in the National Fire Codes, Vol. IV, Extinguishing and Alarm Equipment 1951 (revised to January 1) and by the National Board of Fire Underwriters in NBFU Pamphlet No. 20, August 1948.

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. These editions have incorporated appropriate provisions to cover new developments and obsolete provisions have been omitted. NFPA action on successive editions has been taken in the following years: 1907, 1910, 1911, 1912, 1913, 1915, 1918, 1919, 1920, 1921, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1931, 1932, 1933, 1937, 1939, 1943, 1944, 1946, 1947 and 1948. Further information will be found in the historical statement on centrifugal fire pumps published in the National Fire Codes, Vol. IV, and full details of all NFPA actions will be found in the NFPA Proceedings for the years indicated.

STANDARDS FOR THE INSTALLATION AND OPERATION OF CENTRIFUGAL FIRE PUMPS.

TABLE OF CONTENTS.

Introduction.

1. The centrifugal pump is well adapted for driving by an electric motor, steam turbine or internal combustion engine as the speed of the pump and the prime mover will usually be the same, thus permitting direct connection.

2. Fire pumps are specially designed to meet the following rules. Standard sizes are 500, 750, 1000, 1500, 2000 and 2500 G.P.M. Standard pressures are 100 lbs. or more. These are known as standard fire pumps. Pumps for above capacities for pressures 40 to 100 lbs. are known as low pressure fire pumps or booster pumps. Any of the above may be horizontal, single or multi-stage pumps, or vertical shaft turbine type pumps.

Special Fire Service Pumps are rated at 200, 300 and 450 G.P.M. limited to 130 per cent capacity maximum and for varying pressures with loads not greater than 30 hp. motor rating.

3. Careful consideration must be given in each case to the dependability of the power supply, not overlooking the possible effect of fire in the property or in adjoining buildings which might threaten the property.

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

5. The pump, driver, bed plate and all necessary attachments shall be purchased under a unit contract stipulating compliance with these standards and satisfactory performance of the entire unit when installed. Pump and driver should be assembled and tested as a unit, by the pumper manufacturer.

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.

6. These standards require centrifugal 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 825(c)
Circulation relief valve, Section 120
Eccentric tapered reducer at suction inlet, Section 113(e)
Hose valve manifold with hose valves, Section 116
Pressure gauges, Section 118
Priming connection, Section 114
Relief valve and discharge cone, Section 115
Splash shield between pump and motor, Section 204(i)
Test valve with piping connections, Section 117

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

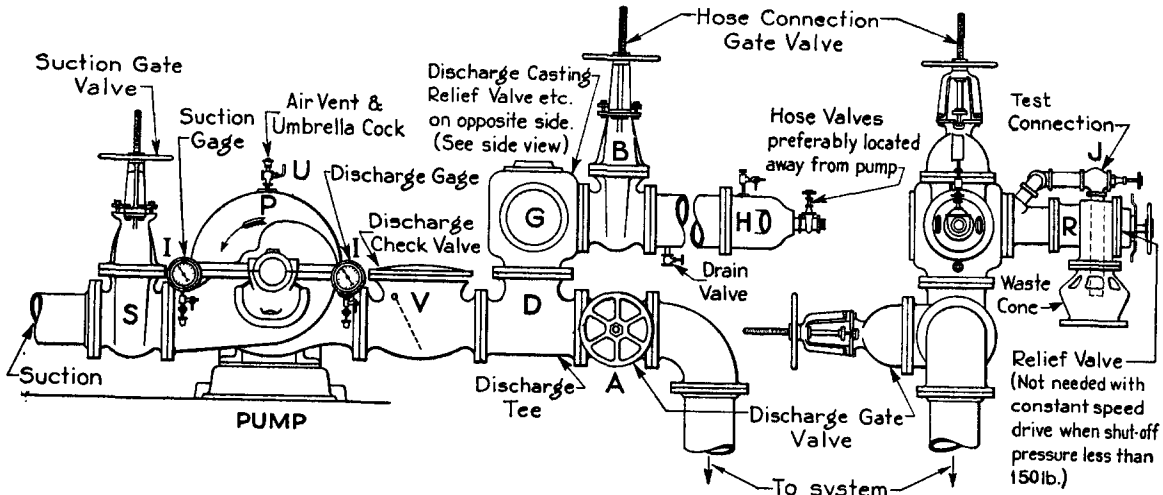

Fig. 6a: Centrifugal Fire Pump Installation Where Pump Takes Water Always Under a Head.

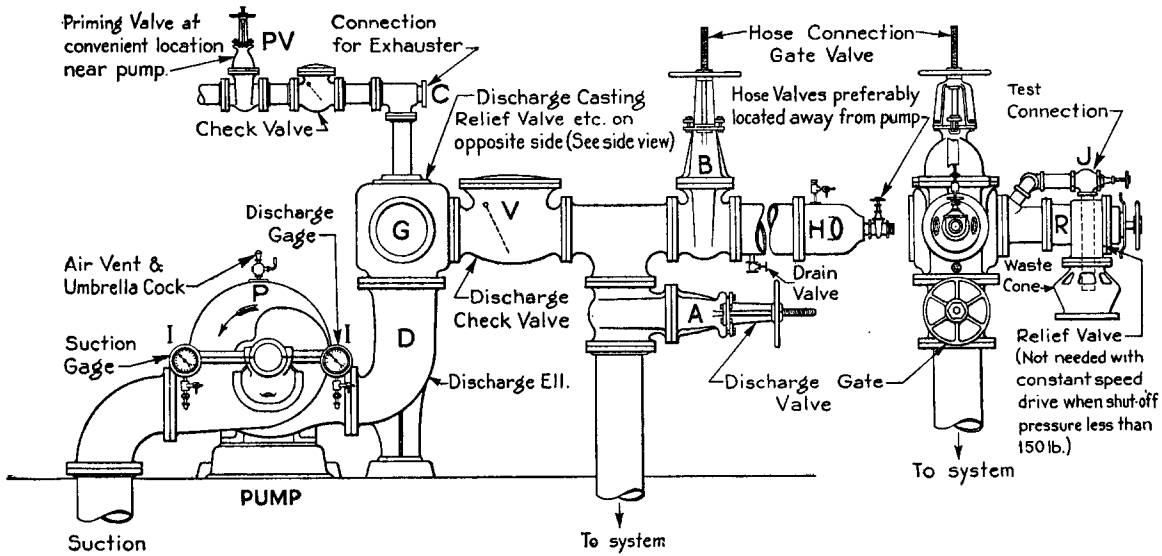

Fig. 6b. Centrifugal Fire Pump Installation Where Pump Has Suction Lift.

7. The maker shall test each pump hydrostatically before shipment from the factory, to twice the working pressure but in no case to less than 250 pounds per square inch. Pump casings shall be substantially tight at the test pressure.

8. 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.

10. Selection of Pump.

101. Centrifugal fire pumps shall be specifically approved for fire pump service.

102. Centrifugal fire pumps shall be chosen for the conditions under which the pumps are to be installed. The selection of a pump for a given situation requires considerable engineering judgment based on a knowledge of the conditions under which the pump must operate. The authority having jurisdiction should be consulted as to the proper type and size of pump to be used.

103. Pumps shall furnish not less than 150 per cent of rated capacity at a pressure not less than 65 per cent of rated pressure. The shut-off pressure for horizontal shaft pumps should not exceed 120 per cent of rated pressure. The shut-off pressure for vertical shaft pumps should not exceed 140 per cent of rated pressure.

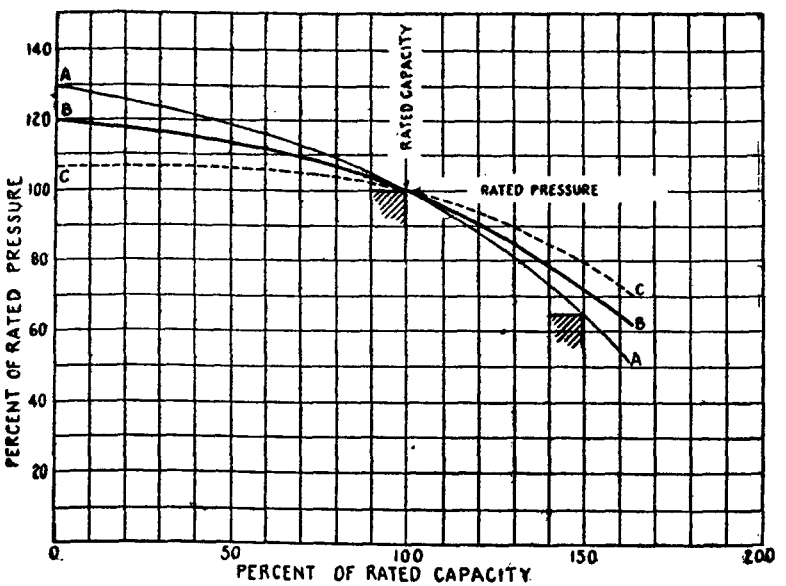

Fig. 103. Characteristic Curves.

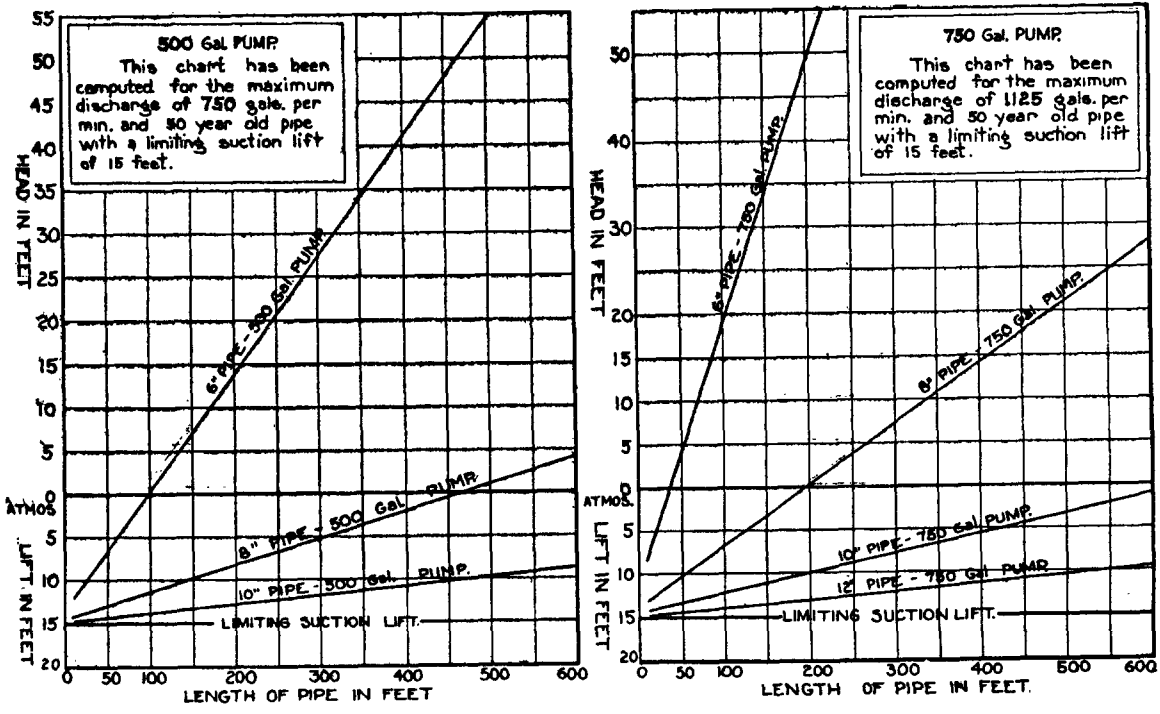

Fig. 113c-1. Charts for Determining Suction Pipe Sizes.

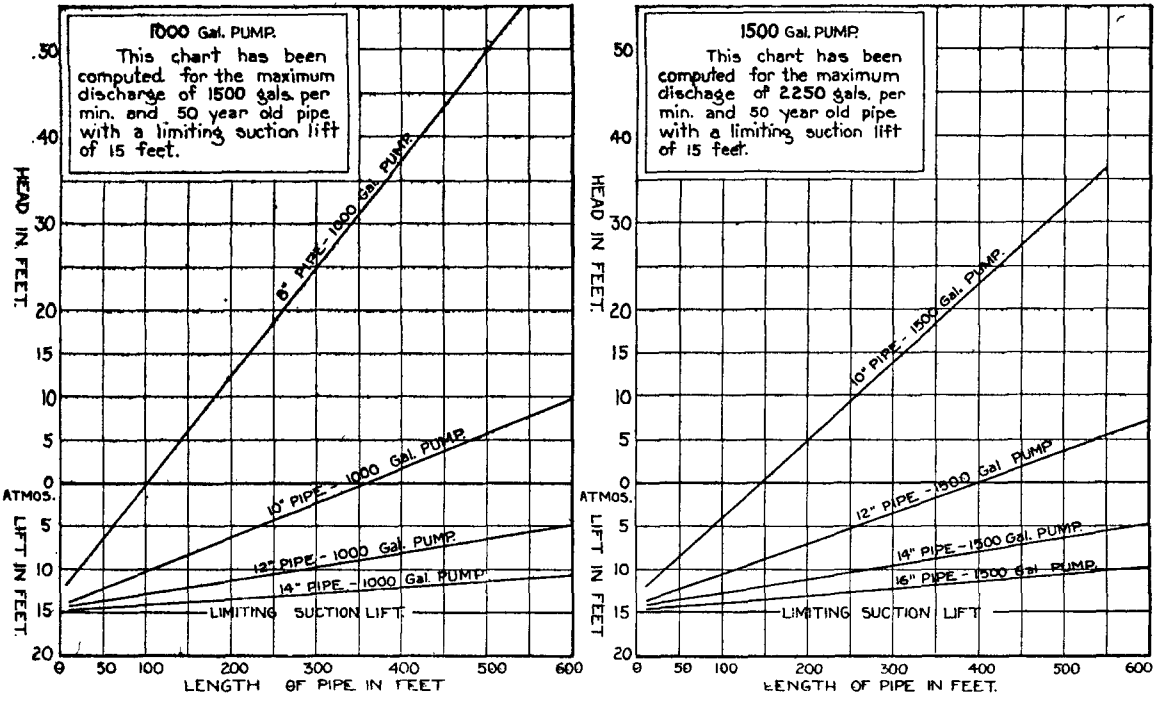

Fig. 113c-2. Charts for Determining Suction Pipe Sizes.

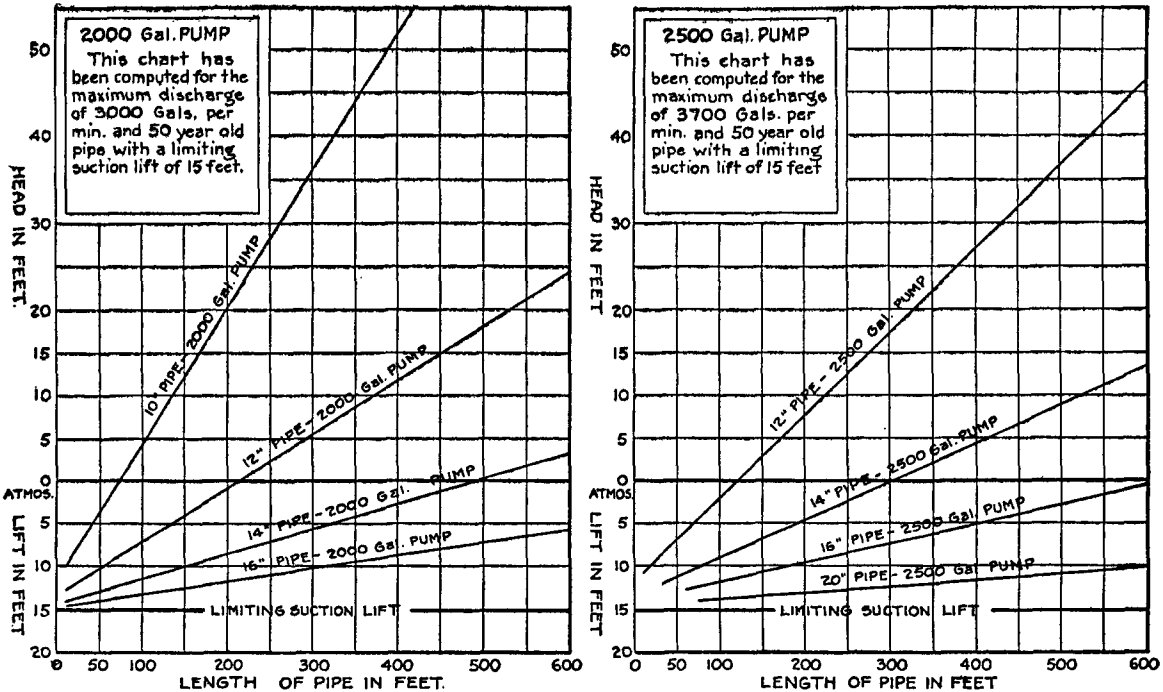

Fig. 113c-3. Charts for Determining Suction Pipe Sizes.

104. 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.

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

105. For requirements on capacity and pressure refer to Standards for the Installation of Sprinkler Systems, and Standards for the Installation of Standpipe and Hose Systems, and for hydrants, Standards for Outside Protection.

11. Installation.

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

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

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

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

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

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

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

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

112. 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 bed plate 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 bed plate made solid by grouting with neat cement. After the cement has thoroughly set the bolts shall be tightened.

(e) 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.

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.

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.

113. Water Supplies and Connections.

(a) Fire pumps should be provided with as large and reliable a supply of water as possible. Where a stored supply is the only one available, a reliable method of replenishing the supply should be provided.

(b) Fire pumps, especially those automatically controlled, should be provided with water under a head, avoiding suction lifts wherever possible. Operating suction lifts shall not exceed 15 feet. Where suction lift is

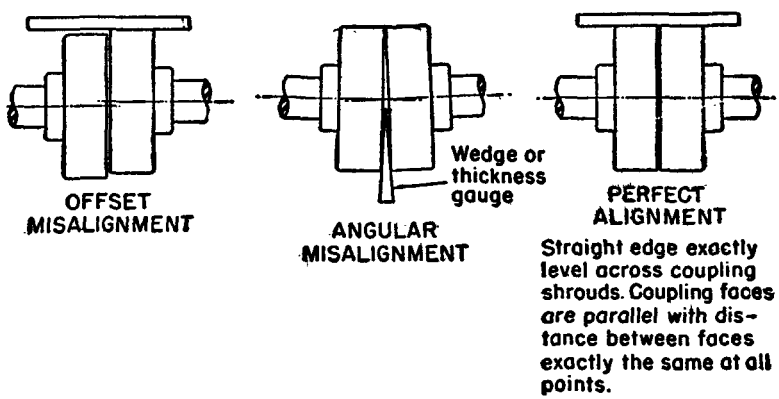

Fig. 112. Proper and Improper Shaft Alignment.

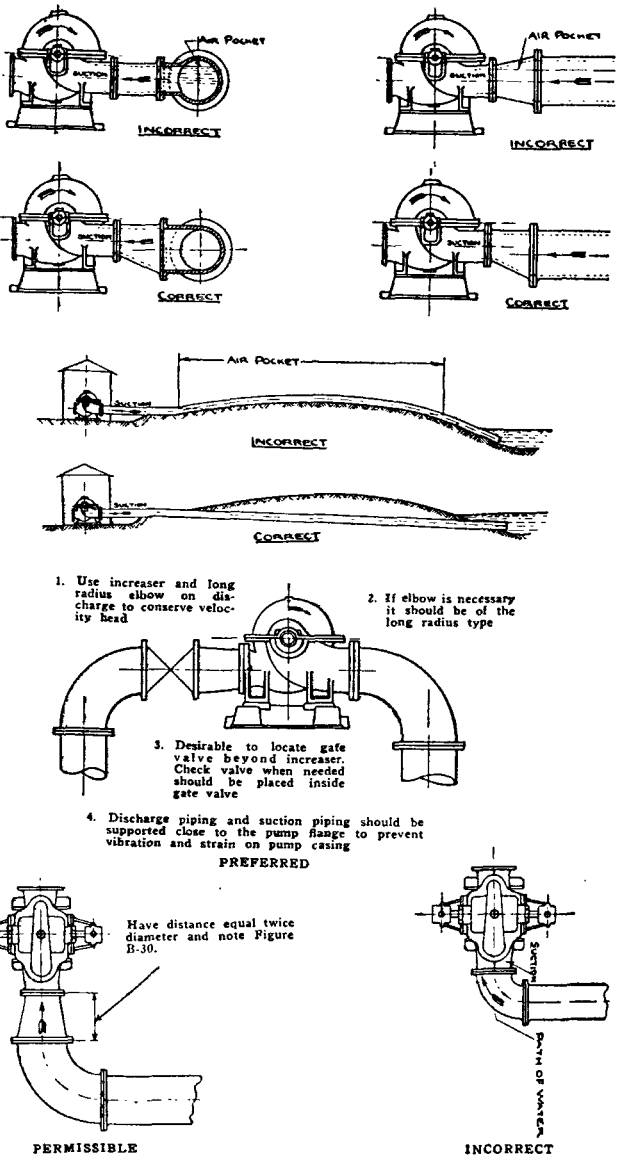

Fig. 113e. Correct and Incorrect Pump Suctions.

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necessary, consideration should be given to the use of a vertical shaft turbine type pump.

(c) The size of suction pipe shall be as determined from Figs. 113c-1, 113c-2 and 113c-3. For elbows an equilavent number of feet of pipe must be added to the length, as given in the following table (for 90° elbows).

Size of elbow, inches	4	6	8	10	12	14	16	20
Equivalent feet of pipe	16	18	24	30	40	54	55	70

For foot valves an equivalent number of feet of pipe should be added as follows:

Size of foot valve, inches	6	8	10	12	14	16
Equivalent feet of pipe	30	40	50	60	70	80

Where two or more pumps use a common suction pipe the charts may be used by taking the combined capacity of the pumps. Where the combined capacity is larger than the charts provide for, the size should be computed using Williams and Hazen coefficient C=60. Loss in the foot valve should be considered.

(d) Where required by the authority having jurisdiction, pumps used to augment the pressure of supplies which would be of material value without the pumps shall be so installed as to permit the direct flow of water to the system, without undue friction loss, when the pump is shut down, as for repairs.

NOTE: By placing the pump in the by-pass direct flow of water is permitted with a minimum of friction loss. Where the pump is installed in a by-pass, a check valve or, where acceptable to the authority having jurisdiction, a gate valve normally kept closed, will need to be installed in the main line between the by-pass connections. See paragraphs 113(j) and 133(k).

(e) 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. Standardized mechanical joint pipe or bell and spigot pipe with calked lead joints should be used. For short pipes well supported, flanged pipe with rubber gaskets may be used. Long suction pipes should be avoided.

The suction pipe should be so laid that it will have a constantly ascending grade from the water supply to the pump. If the suction pipe and pump opening are not of the same size they shall be connected by an eccentric tapered reducer in such a way as to avoid air pockets.

(f) Suction pipes which may at any time involve a lift shall be equipped with approved foot-valves, having bronze seats, clappers faced with a suitable

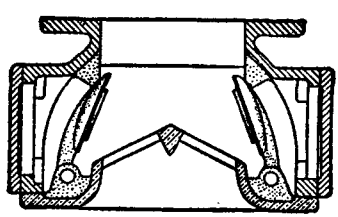


Fig. 113f. Foot Valve of Good Design.

yielding material, and so designed as not to unduly restrict the flow of water. Foot valves shall be readily removable for inspection and cleaning.

(g) Suction inlets should be at least 18 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.

(h) Suitable screens shall be provided at suction intakes where they are 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. Double screens are advised, so arranged that either can be removed for cleaning while the other remains in service. A brass or copper wire screen of one-half inch mesh and No. 10 B. & S. gauge wire, secured to a frame sliding vertically at the entrance to the intake, makes a serviceable arrangement, and permits of ready cleaning and overhauling. Such screens should have an effective area of 1½ square inches for each gallon per minute of rated pump capacity. Combination foot valves and strainers shall not be used.

(i) 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

(j) An approved check valve shall be installed in the discharge pipe.

(k) 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.

114. PRIMING SUPPLIES.

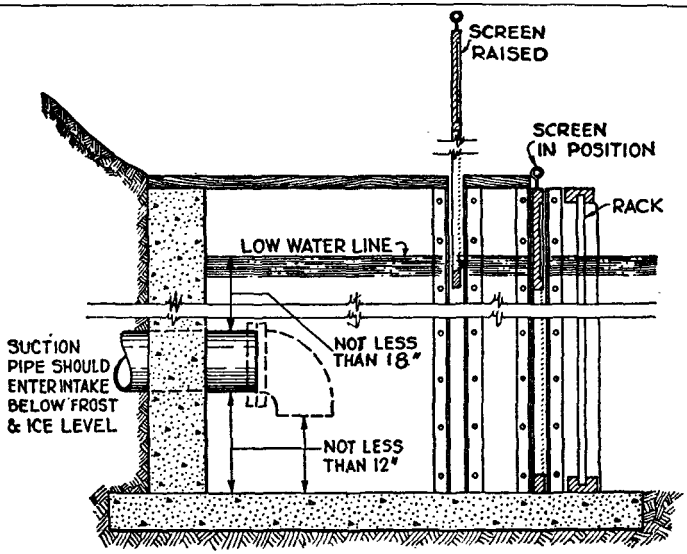
Centrifugal pumps taking suction under a lift shall be provided with priming supplies acceptable to the authority having jurisdiction. Priming equipment shall have sufficient capacity to quickly exhaust the air from the pump and suction pipe; the maximum time in any case should not be over three minutes. There shall be at least one reliable priming supply that is independent of city water connections or tanks serving as primary supplies for automatic sprinklers, yard hydrants or standpipes. One or more additional priming supplies are recommended for emergency use. The following methods are recommended.

No method should be selected which will permit contamination of a potable water supply.

(a) A priming tank of ample capacity with reliable means for filling it. Where the suction pipe and pump are kept filled with water by an automatic float arrangement on the priming tank, the capacity of the priming tank shall not be smaller than that needed to fill the pump and suction pipe. Where the pump and suction pipe are not kept filled with water at all times the capacity of the priming tank shall be not smaller than three times that needed to fill the pump and suction pipe. The tank should be connected to the discharge side of pump at a point which will insure that all priming water enters the pump, and is not wasted in the pipe leading from the pump. This connection should include an approved indicating gate valve and an approved check valve with pipe sizes not less than as follows:

Size of Pump (Gal. per Min.)	500	750	1000	1500-2500
Size of Priming Pipe for Suction Pipe not over 25 feet long	2½"	3"	3½"	4"

For longer suction pipes, larger priming connections may be required.



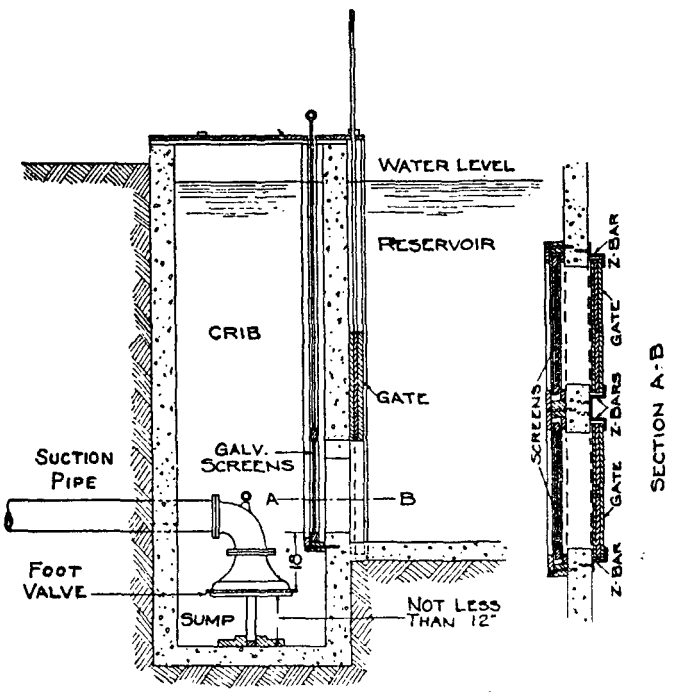


Fig. 113h. Two Arrangements of Suction Inlets.

The bottom of the tank should be at least 2 feet above the top of the pump to insure a good working head. Means for keeping tank filled shall be provided—either an auxiliary pump or a connection to a public supply main through a suitable float valve. A connection between fire pump and tank is recommended to permit refilling tank.

NOTE: The liberal priming tank and large connecting pipe are necessary so that the pump can be primed quickly, even if there is considerable leakage at the foot valve. As the priming arrangement is so vital a feature to the successful starting of the pump, a considerable factor of safety is needed.

(b) A Connection to the Domestic Water System. Approved check and indicating gate valves should be installed in the priming pipe near the pump.

(c) A Connection to Domestic-Use (service) Tank, preferably arranging a reserve supply for priming only, by extending service riser up into the tank. Approved check and indicating gate valves should be installed in the priming pipe near the pump.

(d) An Ejector. Where a reliable steam supply or separate water supply under good pressure is available, a liberal sized exhauster or siphon ejector may be connected up between the pump and discharge check valve to exhaust the air from the pump and the suction pipe.

(e) A Mechanically-Operated Exhauster driven by a separate motor, designed to quickly pump the air out of the suction pipe and pump.

The exhauster should be connected between pump and discharge check valve, so as to completely fill suction pipe and pump. An approved indicating gate valve should be placed in the exhauster connection, to be closed as soon as pump is primed.

(f) A Special Priming Pump. Where the conditions warrant, such as an unusually long suction pipe, a small centrifugal pump driven by a separate motor or other power may be used preferably with the pump submerged, and its discharge connected between the main fire pump and its discharge check valve. This will enable the entire main suction pipe, including the pump, to be completely filled prior to the starting of the main pump. In case it is not practicable to submerge the priming pump, a moderate sized tank shall be provided for priming it, arranged as outlined in paragraph (a).

A mill-use pump can be connected to the fire pump in this manner.

(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, it may be made available for priming by installing a 2-inch by-pass around the check valve in the pump discharge pipe.

NOTE: This method is acceptable only in conjunction with an independent priming supply.

115. 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 inlet 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.

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.

(d) 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.

(e) 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, ins.	3	3½	4	5	6

(f) 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

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

116. Hose Valves. (a) Approved 2½-inch hose valves of the number specified in paragraph (b) 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) Hose valves should 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.

117. 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.

118. PRESSURE GAUGES. (a) An approved pressure gauge shall be connected near the discharge casting by a ¼-in cock with lever handle. The dial shall indicate pressure up to 240 pounds and shall be marked "WATER." Where the pump takes suction under a lift the gauge shall be of a type that will not be injured by a vacuum.

(b) An approved compound pressure and vacuum gauge shall be connected to the suction pipe near the pump.

119. AUTOMATIC AIR RELEASE. Pumps which are automatically controlled shall be provided with a 1-inch or larger air release valve to automatically release air from the pump.

120. CIRCULATION RELIEF VALVE TO PREVENT OVERHEATING. Pumps which are automatically controlled shall be provided with a ¾-inch or 1-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 subsection 117. Provision should be made for discharge to a drain.

ELECTRICAL DRIVING AND CONTROL OF PUMPS.

200. General.

Electrical equipment shall comply with the National Electrical Code, except as modified or provided herein.

NOTE: See Par. 322 of the NFPA Standards for Installation of Sprinkler Systems (No. 13) regarding supervision of centrifugal fire pumps constituting the sole sprinkler supply.

201. Power Station.

(a) When current is taken from a single power station, the station should be of non-combustible 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.

(b) Where current is taken through a sub-station this sub-station should also meet the requirement of paragraph (a) 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.

(c) 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.

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.

202. Power Supply 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.

All wiring in the pump room shall be in approved conduit.

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.

(b) 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, will not be exceeded by the load carried.

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

(c) 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 Section 222 regarding overcurrent protection for the motor branch circuit conductors.

203. Transformers.

(a) Transformers shall be installed in accordance with the requirements of the National Electrical Code. If in the transformer room, there should be access from the outside of the building.

(b) 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.

(c) 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.

204. Motors.

(a) 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 paragraph (b). 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:

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.

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 or auto-transformer type starting may be employed, or a wound rotor type of motor with appropriate starting equipment may be substituted.

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*
5	90
7½	120
10	150
15	220
20	290
25	365
30	435
40	580
50	725
60	870
75	1085
100	1450
125	1815
150	2170
200	2900

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 at other voltages shall be inversely proportional to the voltage. (For example, a 15 h.p.-440 volt motor would have a value of 110 amperes.)

(b) 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. 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.

(c) With a room temperature not exceeding 40° C. (104° F.), open 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.

(d) Where unusual moisture or abrasive dust conditions are anticipated, motors shall be of special type or specially insulated to withstand such conditions.

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

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

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

(g) A nameplate 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.

(h) Motors furnished for centrifugal fire pump use shall be guaranteed to conform with these specifications.

(i) 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.

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.

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

(j) 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.

CONTROLLERS.

GENERAL REQUIREMENTS FOR ALL CONTROLLERS.

211. General.

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.

Voltages above 600 are not recommended for fire-pump service.

212. Mounting.

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

213. Marking.

Motor control equipment conforming to these standards 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. These markings shall be so located as to be visible after installation.

214. 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 224).

215. 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. A circuit breaker used only for the purpose described in paragraph 222 need not be externally operable.

216. 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.

217. Test Connections.

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

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

(b) 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 disconnecting means and the controller.

218. Protection of Auxiliary Circuits.

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

219. Location.

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

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

220. 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 of 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.

NON-AUTOMATIC TYPE—600 VOLTS OR LESS.

221. Disconnecting Means.

An approved disconnecting means shall be provided, having one pole for each wire in the motor branch circuit. Where a single-throw switch is used for motors of 50 horsepower and less, it shall be a motor-circuit switch having a horsepower rating not less than that of the motor; for motors of more than 50 horsepower, it may be a motor circuit switch also rated in amperes or a general-use or an isolating switch rated in amperes. Where a double-throw switch is required, it shall be a general-use or an isolating switch rated in amperes. The ampere rating of ampere-rated switches shall be at least 115 per cent of the rated full-load current of the motor.

The following warning shall be marked on the outside of the enclosure for the disconnecting means: DO NOT OPERATE UNDER LOAD.

222. Circuit Breaker.

The motor branch circuit on the load side of the disconnecting means shall be protected by means of a manually operated circuit breaker having 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 without tripping and shall provide stalled rotor protection and instantaneous short circuit protection. 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. 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. It shall trip free from the handle. The circuit breaker shall be connected in the circuit directly on the load side of the disconnecting means. No other over-current protection devices shall be in the motor circuit on the load side of this circuit breaker.

NOTE: See Section 202(c) for rating and setting of over-current devices in the circuit on the line side of this circuit breaker. See the National Electrical Code for the number of over-current units required for circuit protection devices.

223. 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 without 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.

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.

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.

(b) 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.

(c) UNDERVOLTAGE PROTECTION. Under-voltage protection shall be provided on across-the-line starters where required by local regulations and on all reduced-voltage type starters.

NOTE: The American Standard definition for under-voltage protection is: Under-voltage protection is the effect of a device operated on the reduction or failure of voltage to cause and maintain the interruption of power to the main circuit.

224. 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.

225. 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.

AUTOMATIC TYPE—600 VOLTS AND LESS

231. General.

(a) Control equipment of the automatic type shall comply with the general requirements for all controllers (Sections 211 to 219 inclusive) and with those for non-automatic type (Sections 221, 222, 224 and 225) and, in addition, shall comply with the provisions of the following Sections 232 and 233.

(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.

232. 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 and stopping the motor automatically shall be under the control of a suitable pressure-actuated switch in the control circuit of the starter which is responsive to system pressure; but operation of this switch to stop the motor shall be subject to the time control described in paragraph (c). Controllers for multiple pump units shall incorporate a sequential timing device to start the units at five-second intervals.

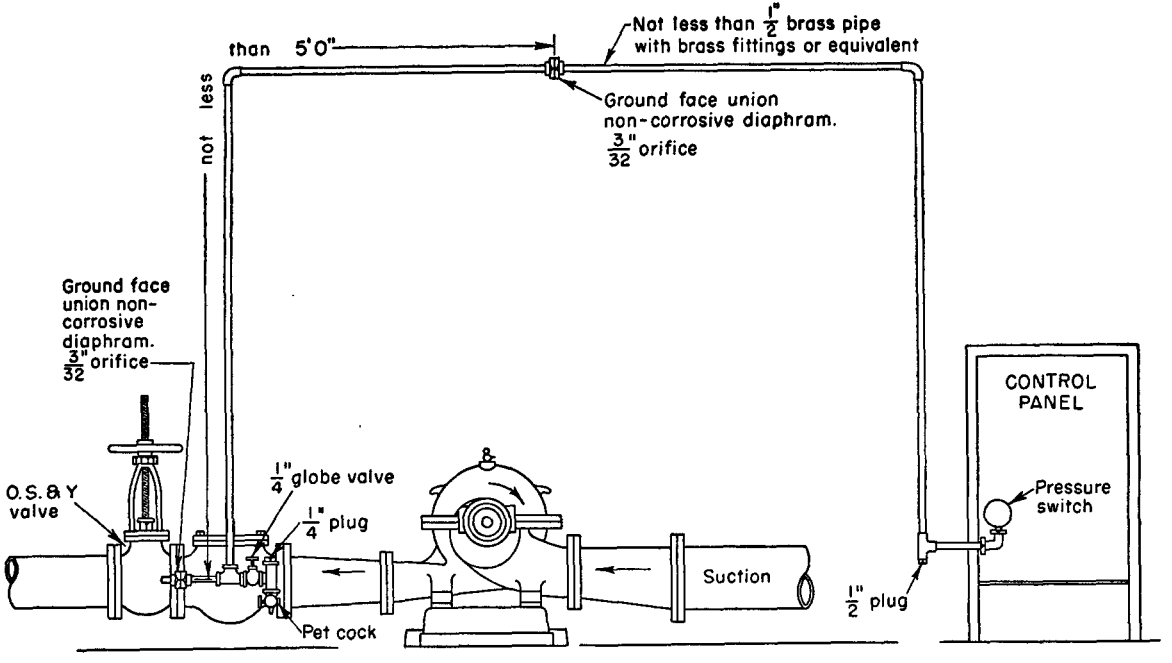


Fig. 231. Piping Connection for Automatic Pressure Switch.

(c) FREQUENCY OF STARTING. In order to insure against too frequent automatic starting of the motor, suitable automatic means shall be provided as a part of the controller to keep the motor running, each time it is started automatically, for a period of one minute for each 10 hp of motor rating, but not to exceed 7 minutes.

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.

(d) 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 switching mechanism mechanically for non-automatic continuously-running operation of the motor, as in the case of the non-automatic controller (Section 223a), independent of the pressure-actuated control switch.

(e) 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.

233. 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.

STEAM TURBINES DRIVING CENTRIFUGAL FIRE PUMPS.

30. General Features.

301. ACCEPTABILITY. 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.

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

302. POWER. (a) For boiler pressures of 120 pounds per square inch gauge 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 gauge 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 gauge 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 (a).

(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.

303. STEAM CONSUMPTION. With 120 pounds per square inch gauge steam pressure or higher at the throttle and atmospheric exhaust, the steam consumption should ordinarily not exceed that given in the following table when running at rated speed and load with the hand valve closed.

The purpose of the recommended maximum steam consumption rates is to obtain turbines of good design which will be less likely to overtax the available steam supply. The availability of adequate steam supply for the turbines is the primary consideration.

STEAM CONSUMPTION.

Size of Pump (gal. per min.)	Speed (r.p.m.)	Maximum Steam Consumption (lb. per H.P. per Hr.)
500	1750	70
	3500	45
750	1750	65
	3500	45
1000	1750	65
	3500	45
1500	1750	60
	2800	45
2000	1750	55
	2500	40
2500	1750	50
	2000	40

NOTE.—For intermediate speeds the maximum steam consumption should be interpolated from the above table.

304. SPEED. The rated speed should not exceed 3500 r.p.m.

NOTE.—Low speed turbines (1750 r.p.m.) are less efficient but are sometimes justified for dual drive in connection with an electric motor.

31. Turbine.

311. 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) Steam and exhaust chambers shall be equipped with suitable drains to relieve accumulations of water when the pump is idle.

(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.

312. 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 5 per cent (as connected) with normal steam pressure and hand valve closed; and at steam pressures down to 80 pounds per square inch gauge, 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 20 per cent higher than rated speed.

313. PRESSURE REGULATOR. (a) For special conditions a pressure regulator may be necessary. It should be placed in a by-pass around the main throttle unless combined with the turbine in such a way that if it failed to function, the speed governor would then control the machine.

(b) Where a pressure regulator is provided, the speed governor need not be made adjustable as mentioned in Section 312 (b), but it should be set at a speed 10 per cent above the rated speed of the pump to limit and control the pump speed if the pressure regulator is out of service for any reason.

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

The gauge shall indicate pressures up to 1¼ times the boiler pressure, but not less than 240 pounds per square inch, and should be marked STEAM.

315. ROTOR. The rotor of the turbine shall be of suitable material and shall be tested in the shop at a speed 40 per cent above rated speed.

316. 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.

317. 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.

318. 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.

32. Installation.

321. 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 disc. If, however, the type of valve having the disc fitted with a removable composition ring is used, the disc should be of bronze and the ring made of sufficiently

hard and durable material and so held in place in the disc 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 section 311 (b) 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.

322. 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.

323. EMERGENCY BOILER FEED. 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.

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.

INTERNAL COMBUSTION ENGINE DRIVING OF CENTRIFUGAL FIRE PUMPS.

400. 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 section 500—Combined Manual and Automatic Controllers for Internal Combustion Engines Driving Centrifugal Fire Pumps.

401. Engines.

(a) Engines shall be specially approved for fire pump service. They shall be specially rugged and reliable, and should be equivalent in all essential respects to the best grades developed for high speed motor boats.

(b) The engine and pump shall be assembled completely in the shop of the pump manufacturer and run continuously at rated load and speed for at least three hours before being shipped to the purchaser.

(c) The engine shall develop at least 10 per cent greater power than is required to operate the pump at rated speed under any conditions of pump load.

NOTE.—It is important that a liberal margin of power be provided above actual requirements to avoid engines showing signs of overload or stress and to provide for normal depreciation of the engine with age. The power generated by internal combustion engines decreases about 3½ per cent for each 1,000 feet elevation above sea level. It is recommended, therefore, that at least 5 per cent additional horsepower be provided for each 1,000 feet of elevation above sea level.

(d) 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.

(e) Dual drive units are not recommended. The use of separate pumps provides greater flexibility and reliability. Where dual drive is used the clutch should be of an automatic type acceptable to the authority having jurisdiction.

(f) 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.

(g) 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.

(h) An oil pressure gauge shall be provided to indicate engine lubricating oil pressure and a temperature indicator to indicate engine cooling water temperature.

(i) All instruments of control such as gauges, switches, indicators and coils should be placed on a suitable board secured to the unit at a convenient point.

(j) Where electric ignition is used the ignition system shall be supplied from a storage battery of ample size for the engine. A high tension magneto of suitable type may be used as a secondary source of ignition.

(k) Gasoline engines shall be equipped with an electric starting device taking current from the storage battery. Diesel engines should preferably be so equipped using heavy duty Diesel type batteries but may be started by other reliable means.

If air starting of Diesel engines is used with air pressure in excess of 100 pounds gauge 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.

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.

(l) Two ways or means for recharging storage batteries shall be provided. One should be the generator furnished with the engine, and the other some form of rectifier if there is available a suitable alternating current. If the power is direct current, a direct connection will suffice with suitable resistance provided.

(m) 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.

(n) Drains for cooling water manifold or heat exchanger and for circulating pump shall be provided to safeguard them against freezing. They shall be so piped that their discharge is visible to the operator. Unless the drains can discharge at a suitable point outside, they should discharge into a cone in the pump room, properly drained.

(o) The engine cooling water system shall include a circulating pump and either a cooling water manifold or a heat exchanger. Suitable connections shall be provided to supply the manifold or heat exchanger with cooling water from the discharge of the fire pump; except that where a manifold is used and the pump takes suction from salt water or water containing considerable foreign material, a separate cooling water tank shall be provided. Where a manifold is used the cooling water line from the discharge of the fire pump shall be provided with a hand valve, a suitable strainer, a reducing valve, and a second hand valve, all installed between by-pass connections with a hand valve in the by-pass. Provision should be made for a pressure gauge to be installed in the cooling water supply system on the engine side of the last control valve. Waste water outlet from the cooling system shall be free and unobstructed by valves or connections from other services, to avoid the possibility of retarding the flow of water from the engine cooling system. Outlet should be one pipe size larger than inlet. Suitable connections shall be provided to permit water to be added to the engine-cooling water system whenever needed.

(p) 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.

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

402. Location.

(a) While it may not always be possible to locate a fire pump driven by an internal combustion engine in a separate pump house it is in every case highly important that the pump room be wholly cut off by non-combustible 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.

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

403. Gasoline Supply.

(a) 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.

(b) 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 life will not exceed 6 feet. Fuel pump suction lines shall be copper tubing at least ⅜ in. 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.

(c) 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.

(d) 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.

(e) A suitable flexible connection shall be provided in the fuel line where it connects to the engine.

404. Gravity System of Gasoline Supply.

(a) In the gravity system a small service tank, as shown in Fig. 404, containing about a half hour's supply for the engine feeds the carburetor under a head of two or three feet. A standard small hand pump of approved make shall be provided to keep this service tank properly supplied.

(b) The size of this service tank should not exceed the following capacities:

500 gallon pump	5 gallons
750 " "	5 "
1000 " "	7½ "
1500 " "	10 "

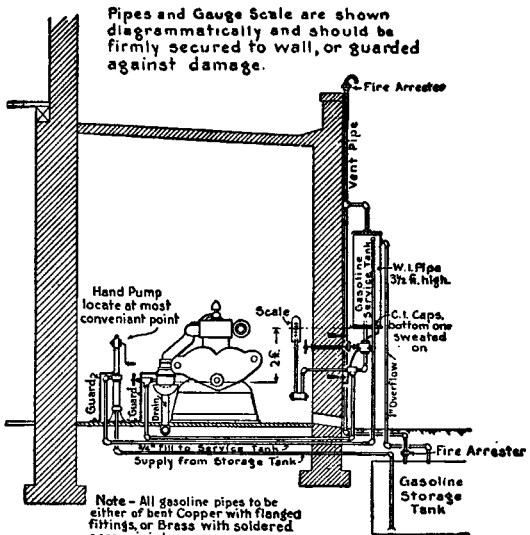


Fig. 404. Gravity System.
Arrangement of Gasoline Feed for Gasoline Engine Fire Pumps.

(c) A valve should be located in the discharge pipe at this tank controlled by an extension stem from the inside of the pump room.

(d) This service tank should be provided with an overflow pipe connected at the top and discharging back into the underground storage tank.

(e) A suitable gauge showing the amount of gasoline in the service tank shall be provided, so located that it will be readily accessible for inspection and protected from injury. Fig. 404e shows a simple form of gauge which is considered safe. The usual form of glass gauge connection shall not be employed. For this indicator or level gauge and its connections only iron pipe should be used, as mercury would amalgamate with the brass or copper pipe.

(f) A substantial one-half inch drain cock connection at the bottom of the service tank should be provided to permit of completely draining the contents of this tank to a safe point outside the pump room. This cock shall be provided with a plug to safeguard against meddlesome opening.

405. Pumping System of Gasoline Supply.

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. 405 for a suggested arrangement. This may be modified to suit the conditions, subject to approval by the authority having jurisdiction.

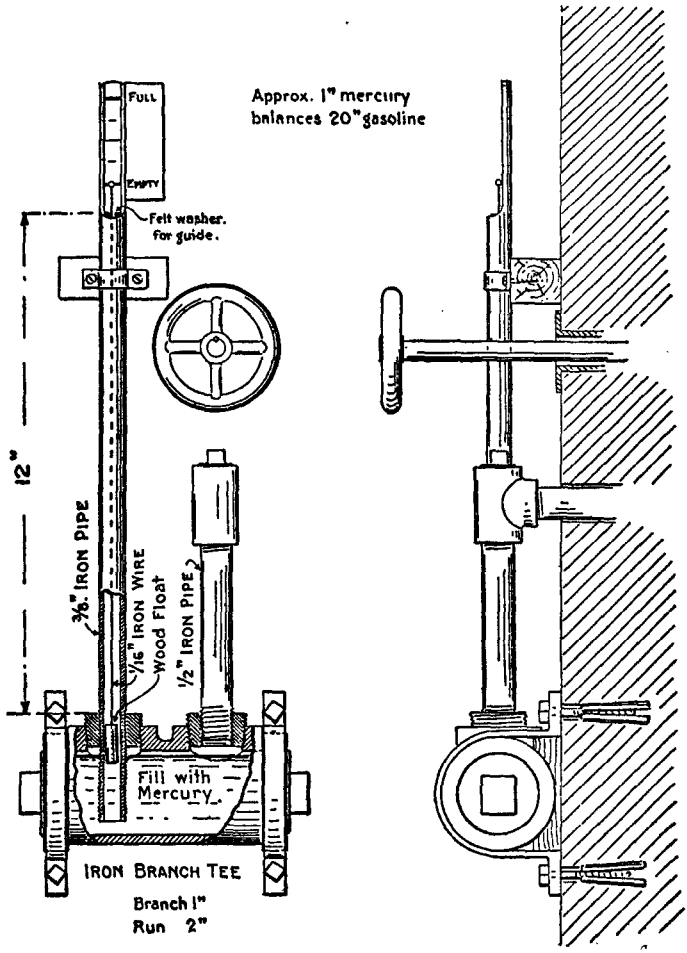


Fig. 404e. Detail Sketch of Gauge Scale.

406. Fuel Supply 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

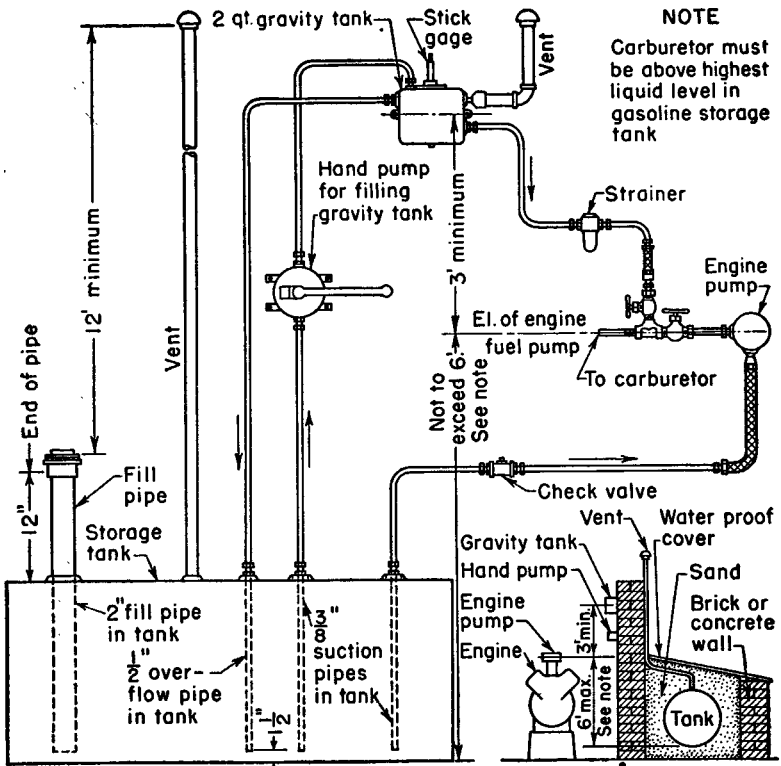


Fig. 405. Pumping System.

Arrangement of gasoline feed is shown schematically. See sections 405 and 407. The valve in the line from the two quart tank to the carburetor is normally kept closed.

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.

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 gauging, oil pumps, valves, pre-heating and maintenance shall be in accordance with the Standards for Oil Burning Equipments (NFPA No. 31). The following sections, quoted from these standards apply to inside storage:

Unenclosed inside storage tanks and auxiliary tanks shall not be located within 5 feet, horizontally, of any fire or flame.

Oil supply tanks located inside buildings shall not exceed 275 gallons individual capacity or 550 gallons aggregate capacity in an individual

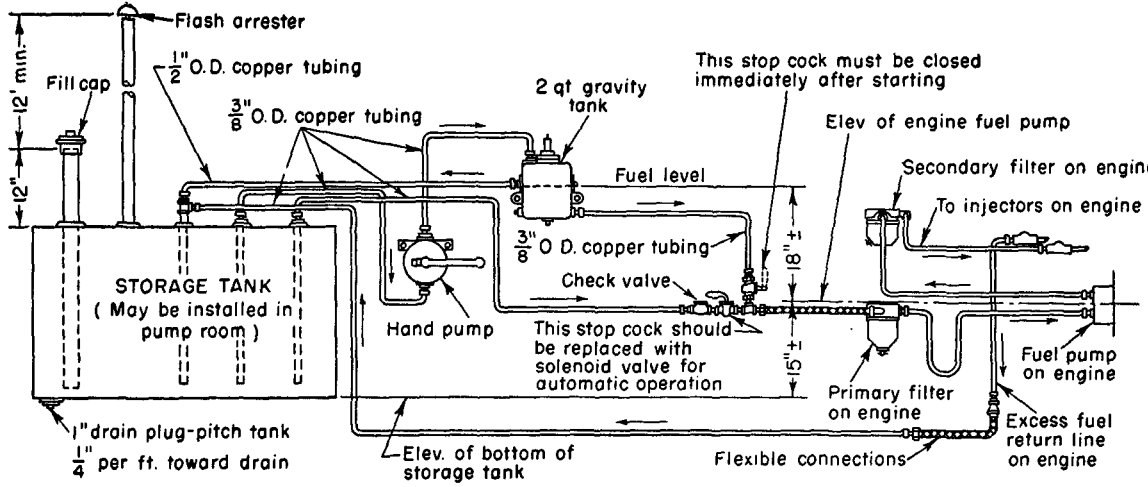


Fig. 406. Suggested Arrangement for Fuel System Priming, Starting and Operation of Diesel Unit.

building or in sections of a building separated by fire walls, unless installed in an enclosure or casing constructed as follows:

The walls of the enclosure shall be constructed of reinforced concrete at least 6 inches thick or of brick at least 8 inches thick. Such enclosures shall be installed only on concrete or other fire-resistive floors and shall be bonded to the floors. Enclosures shall have tops of reinforced concrete at least 5 inches thick or equivalent fire-resistive construction, except that where floor or roof construction above the enclosure is concrete or other fire-resistive construction the walls may be extended to and bonded to the underside of the construction above in lieu of the provision of a separate top. Any openings to such enclosures shall be provided with fire doors or other approved closures. Provision shall be made for adequate ventilation of such enclosures prior to entering for inspection or repairs on tanks.

Instead of an enclosure as above described the tank may be encased in reinforced concrete not less than 6 inches in thickness, applied directly to the tank so as to completely eliminate any air space.

Inside storage and auxiliary tanks shall be securely supported by substantial incombustible supports to prevent settling, sliding or lifting.

It is recommended that inside storage tanks be provided with draw-off or drain openings. When draw-off or drain openings are provided the tanks shall be installed with the bottom pitched to the draw-off or drain opening with a slope of not less than ¼ inch per foot of length. The draw-off or drain opening shall be provided with suitable pipe connections in a form to provide a sump from which water or sediment can be readily drained at regular intervals.

407. Fuel and Exhaust Piping.

(a) All gasoline piping between tanks and between tanks and engines should be approved seamless copper tubing with flared joints or brass pipe with soldered screwed joints.

(b) There shall be provided a guard or protecting pipe at all pipes exposed above the floor.

(c) 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.

408. Maintenance.

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

(b) 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.

(c) 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.

(d) The engine should be kept clean and dry and well lubricated.

(e) 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.

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

(g) The pump room shall be maintained at all times above the freezing point.

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

(i) Spare parts of such portions of the machine as may be expected to give trouble should be kept on hand.

COMBINED MANUAL AND AUTOMATIC TYPE CONTROLLERS FOR INTERNAL COMBUSTION ENGINES DRIVING CENTRIFUGAL FIRE PUMPS.

500. General.

(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.

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

(d) 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. The Standards for the Installation of Sprinkler Systems (Edition of 1951) do not provide for the acceptance of automatically started internal combustion engine driven fire pumps as the sole supply for automatic sprinkler systems.

501. Mounting.

(a) 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 401(j).

(b) The panel shall be securely mounted.

502. Equipment.

(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 gauge.

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

(d) 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.

(e) Signals as indicated in the following shall be provided for:

1. A pilot lamp connected in the starting motor circuit indicating the presence of voltage on the line.
2. 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.

(f) Suitable provision shall be made for relieving pressure to the pressure switch to test the operation of the controller and the pump (see Fig. 231).

(g) All control switches shall be within locked cabinets having break-glass panels.

(h) An electrically controlled valve shall be installed in the cooling water piping from the fire pump discharge in addition to the equipment required by paragraph 401(p).

(i) 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, a tapering type charger shall be provided for each battery.

(j) A suitable automatic choke shall be provided on a gasoline engine to facilitate starting.

503. Wiring.

(a) A wiring diagram shall be provided and permanently attached to the control panel, preferably on the rear side.

(b) All wiring leading from the panel to the engine and battery shall have adequate carrying capacity and shall be protected against mechanical injury.

504. Marking.

(a) 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.

(b) All terminals shall be plainly marked to correspond with the wiring diagram furnished.

505. Location.

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 ft. should be provided at the rear of the panel to permit inspection and servicing.

506. Installation.

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

507. Maintenance.

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.

TESTS FOR ACCEPTANCE.

601. Field Acceptance Tests.

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.

(a) At rated speed, 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 150 per cent of its rated capacity at a net head in conformity with the head-capacity curve specified by the authority having jurisdiction (see Section 103) and without objectionable heating of bearings or of prime mover.

(c) With all discharge outlets (including relief valve) closed, the net shut-off pressure shall be in conformity with the head-capacity curve specified by the authority having jurisdiction (see Section 103).

(d) 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.

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

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.

(f) 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.

(g) Manual controllers for electric pumps shall be put through not less than ten complete operations.

(h) Combined manual and automatic controllers shall be put through not less than ten automatic and ten manual operations. 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.

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

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

VERTICAL SHAFT TURBINE-TYPE FIRE PUMPS.

801. General.

(a) These standards apply to vertical shaft turbine-type fire pumps. These pumps shall be specifically approved for fire pump service.

(b) 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.

(c) Wells should not be used for fire pump service where the column length would be greater than 50 feet except where due to multiple units or other conditions the use of a longer column length would be acceptable to the authority having jurisdiction.

(d) The adequacy and the dependability of the source of water is 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. Representatives of the pump manufacturer shall assist in establishing these facts to the satisfaction of the authority having jurisdiction.

(e) 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.

(f) 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.

802. Performance.

(a) There are six standard sizes of vertical shaft turbine-type fire pumps, namely, 500, 750, 1,000, 1,500, 2,000, 2,500 g.p.m. Pressure ratings of head shall be measured just beyond the discharge elbow of the pump. In addition to the discharge pumping head the pump shall develop sufficient additional head to lift the water from the lowest pumping water level to the center line of the discharge elbow. Total head is the distance from the water level in the pit or well when pumping to the center of the discharge gauge, plus the discharge pressure gauge reading.

(b) Pumps shall furnish not less than 150 per cent of rated capacity at a pressure of not less than 65 per cent of the rated pressure. The shut-off pressure shall not be greater than 140 per cent of rated pressure at rated capacity.

810. Water Supply.

811. SOURCE.

(a) The water supply shall be acceptable to the authority having jurisdiction. Stored water supplies from lakes, streams and open reservoirs or tanks supplying wet pits are preferable. Ground water supply taken from thoroughly tested wells will be accepted.

(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.

812. 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.

(c) WELL INSTALLATIONS. Submergence of the pump bowls should be 10 feet below the pumping water level at 150 per cent of normal capacity.

813. 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.

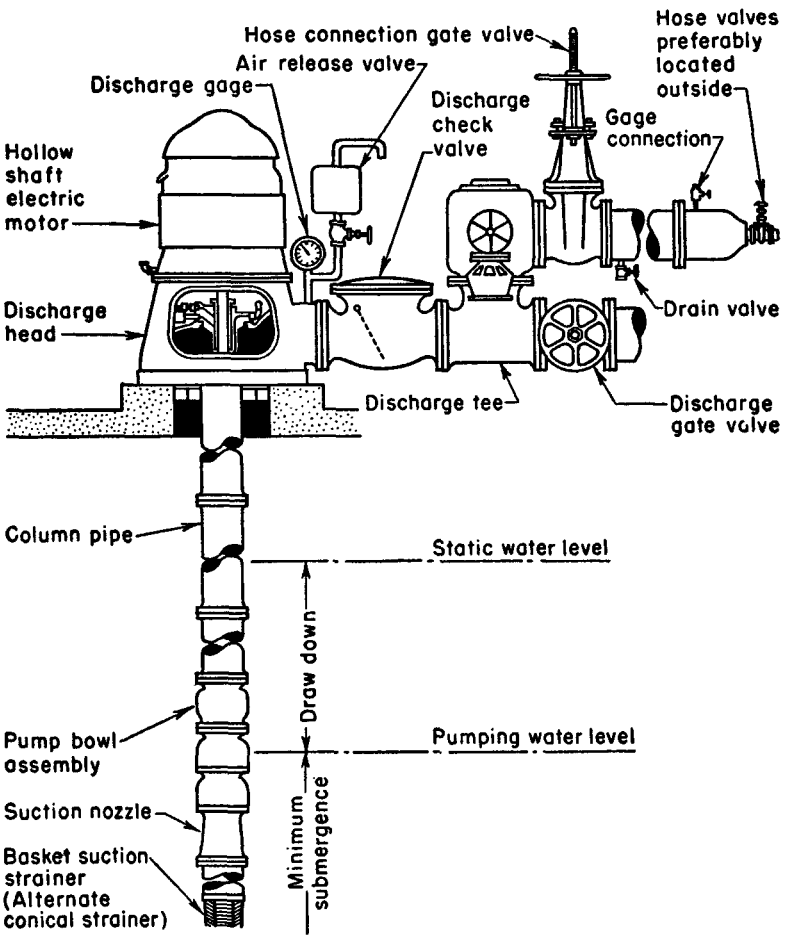


Fig. 801. Vertical Shaft Turbine-Type Pump Installation.

(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) The outer casing shall extend down to approximately the water bearing formation. The inner casing of lesser diameter and screen shall extend into the water bearing formation as specified under Submergence, Section 812 (c).

(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 of the water leaving the water bearing formation and entering the well.

814. 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) An appreciable quantity of air or gas in the water will cut down the performance of the pump and will cause the pump to deteriorate sooner than under normal conditions.

815. PRELIMINARY TEST AND INSPECTION.

(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.

(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.

820. Pump.

821. DISCHARGE HEAD.

The discharge head should be of the aboveground type. (See Fig. 801.) 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.