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Standards for the Installation and Operation of CENTRIFUGAL FIRE PUMPS

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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 eighty-five national and regional societies and assocations and nearly fifteen 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.

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 21, 1953, on recommendation of the Committee on Fire Pumps, intended to bring the standards up to date. This edition supersedes that published in the National Fire Codes, Vol. IV, Extinguishing and Alarm Equipment 1951.

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, 1948, 1951, and 1953. 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.

Previous editions of these standards have been adopted and published by the National Board of Fire Underwriters; it is anticipated that the present revised edition will be similarly adopted and published in due course as NBFU Pamphlet No. 20.

STANDARDS FOR THE INSTALLATION AND OPERATION OF CENTRIFUGAL FIRE PUMPS.

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DEFINITION OF TERMS

The official NFPA definitions of shall, should and approved are:

SHALL is intended to indicate requirements.

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

APPROVED refers to approval by the authority having jurisdiction.

Units of measurement used here are U. S. standard. 1 U. S. gallon = 0.83 Imperial gallons = 3.785 liters.

APPROVED EQUIPMENT

The National Fire Protection Association does not "approve" individual items of equipment. The standards are prepared, as far as practicable, in terms of required performance, avoiding specification of materials, devices or methods so phrased as to preclude obtaining the desired results by other means. The suitability of devices and materials for installation under these standards is indicated by the listings of nationally recognized testing laboratories, whose findings are customarily used as a guide to approval by agencies applying these standards. Underwriters' Laboratories, Inc., Underwriters' Laboratories of Canada and the Factory Mutual Laboratories test devices and materials for use in accordance with the appropriate standards, and publish lists which are available on request.

GENERAL.

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. Larger sizes may be used in specially engineered applications. 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 pump 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, Sections 121 and 225(c)
Circulation relief valve, Section 122
Eccentric tapered reducer at suction inlet, Section 114(i)
Hose valve manifold with hose valves, Section 118
Pressure gauges, Section 120
Priming connection, Section 116
Relief valve and discharge cone, Section 117
Splash shield between pump and motor, Section 404(i)
Test valve with piping connections, Section 119

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

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. In the majority of cases a commercial pump having a capacity of 20 to 50 gallons per minute and suitable characteristics will be satisfactory. The pump should be of centrifugal type.

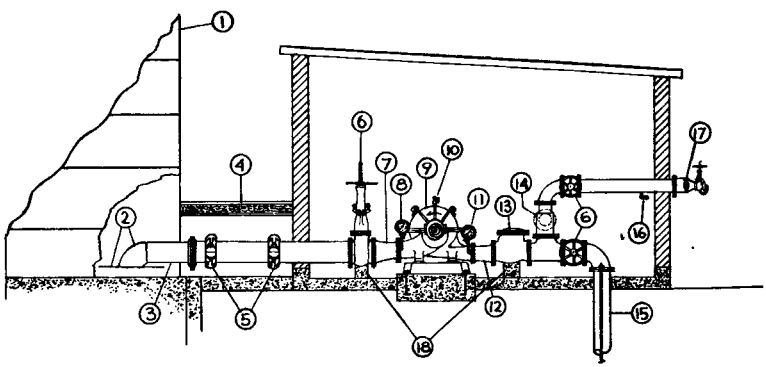

Fig. 6a
Centrifugal Fire Pump Installation where Pump Takes Water Always Under a Head

1. Above Ground Suction Tank.
2. Entrance Elbow and 4 x 4 ft., square vortex plate, 4 in. above bottom of tank.
3. Suction Pipe.
4. Frostproof Casing.
5. Flexible Couplings.
6. O. S. & Y. Gate Valves.
7. Eccentric Reducer.
8. Suction Gauge.
9. Horizontal Fire Pump.
10. Umbrella Cock or Automatic Air Release.
11. Discharge Gauge.
12. Concentric Reducer.
13. Discharge Check Valve.
14. Relief Valve (if required).
15. Discharge Pipe.
16. Drain Valve or Ball Drip.
17. Hose Valve Manifold with Hose Valves.
18. Pipe Supports.

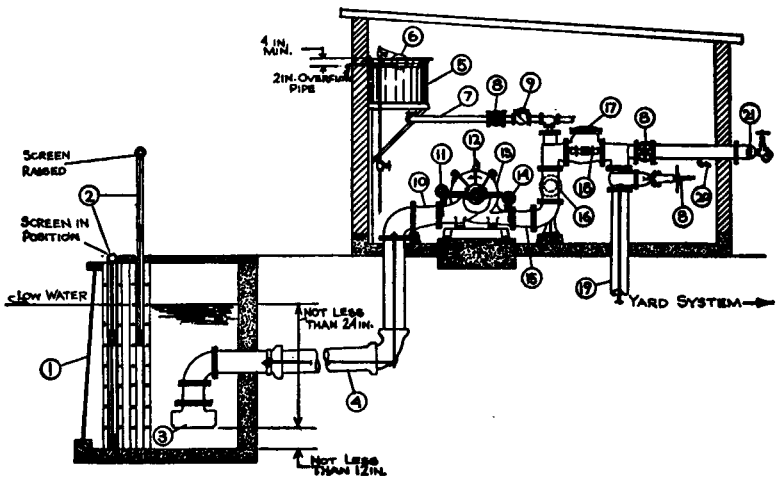

Fig. 6b

Centrifugal Fire Pump Installation Where Pump has Suction Lift

1. Trash Rack (½ in. flat or ¾ in. Round Steel Bars Spaced 2 to 3 in. apart).
2. Double Screens.
3. Approved Foot Valve.
4. Suction Pipe from Water Supply to Pump.
5. Priming Tank.
6. Automatic Float Valve.
7. Priming Connection.
8. O. S. & Y. Gate Valves.
9. Priming Check Valve.
10. Eccentric Reducer.
11. Suction Gauge.
12. Umbrella Cock.
13. Horizontal Fire Pump.
14. Discharge Gauge.
15. Concentric Reducer.
16. Relief Valve (if required).
17. Discharge Check Valve.
18. Priming By-Pass.
19. Discharge Pipe.
20. Drain Valve or Ball Drip.
21. Hose Valve Manifold with Hose Valves.

Selection of Pump.

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

12. 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.

13. 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 shall not exceed 140 per cent of rated pressure.

14. 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.

15. 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.

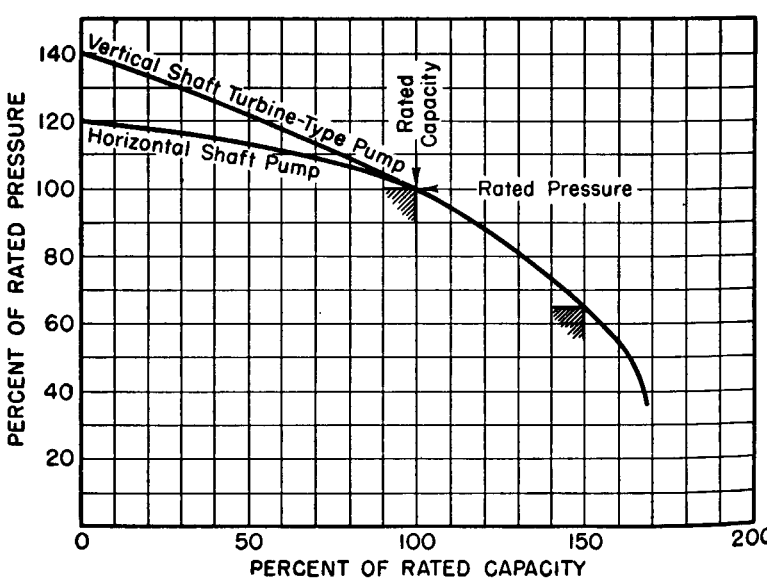

Fig. 13. Characteristic Curves.

HORIZONTAL SHAFT PUMPS.

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. For further information see Instructions for Installing Centrifugal Pumps in Centrifugal Pump Section of the Standards of the Hydraulic Institute.

(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.

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

113. WATER SUPPLIES.

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

114. SUCTION CONNECTIONS.

(a) The size of suction pipe should be determined from Fig. 114a. These curves include an allowance for velocity and friction loss through elbows and foot valves.

(b) Suction pipe should be of the same pressure rating as the yard piping. Use bell and spigot cast iron pipe with calked lead joints or

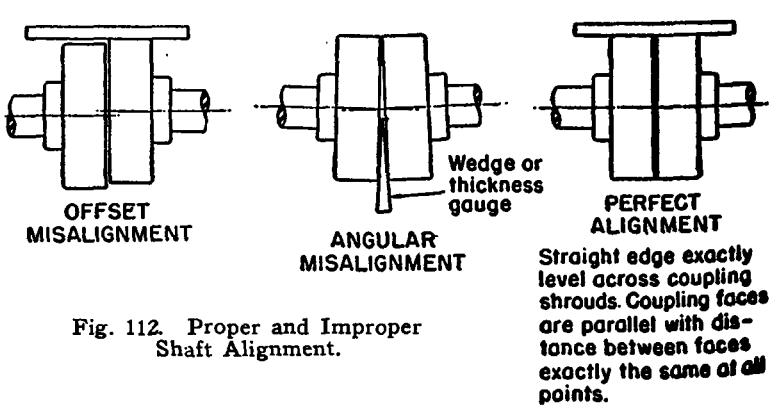

Fig. 112. Proper and Improper Shaft Alignment.

standardized mechanical joint pipe. For short pipe, well supported, flanged cast iron pipe with rubber gaskets should be used. In special cases steel pipe having flanged or screwed joints (flanged joints with flanges welded to the pipe are preferred) may be used above ground in the pump room provided it is painted on the inside, prior to installation, with a paint recommended for submerged surfaces. Thick bituminous coatings applied at the plant should not be used. The exterior of steel pipe should be kept painted. Cement asbestos pipe may be used when the pump takes suction under a head at all times.

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

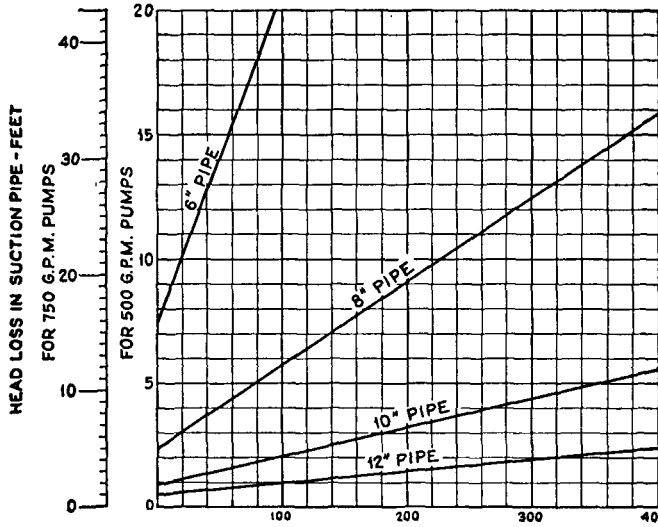

Fig. 114a-1

Chart for Determining Size of Suction Pipe on Pumps of 500 and 750 GPM Capacity

These charts: (1) Are based on flow of 150% of rated capacity of pump and head loss calculated on the basis of C = 70 from Williams & Hazen Hydraulic Tables. (2) Have a head loss at 0 length of suction pipe which is made up as follows: 28% due to loss in foot valve, 56% due to loss in three elbows, and 16% due to velocity head.

This head loss at 0 length may be changed in accordance with these percentages when a foot valve is not required or there is a difference in the number of elbows. *Example*: Assume 1000 gpm. pump taking suction under lift with pumping water level at 150% of rated pump capacity 6 ft. below pump center line. Suction pipe is to be 50 ft. long. What is the minimum size suction pipe required so that the maximum allowable suction lift of 15 ft. will not be exceeded? Maximum allowable head loss in suction pipe = 15 ft. — 6 ft. = 9 ft.

Enter chart for 1000 gpm. pump at 9 ft. head loss in suction pipe. Move along ordinate to 50 ft. This point falls between the curves for 8 and 10 in. pipe. Therefore 10 in. pipe is the minimum size suction pipe required so that the maximum allowable suction lift of 15 ft. will not be exceeded.

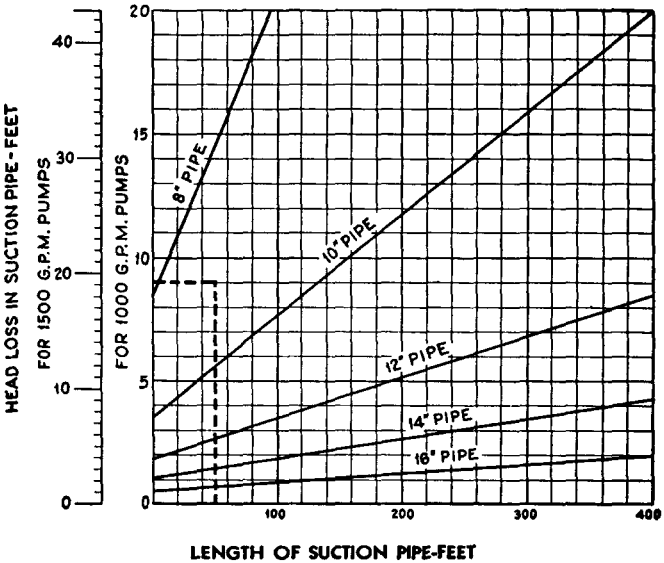

Fig. 114a–2
Chart for Determining Size of Suction Pipe on Pumps of 1000 and 1500 GPM Capacity

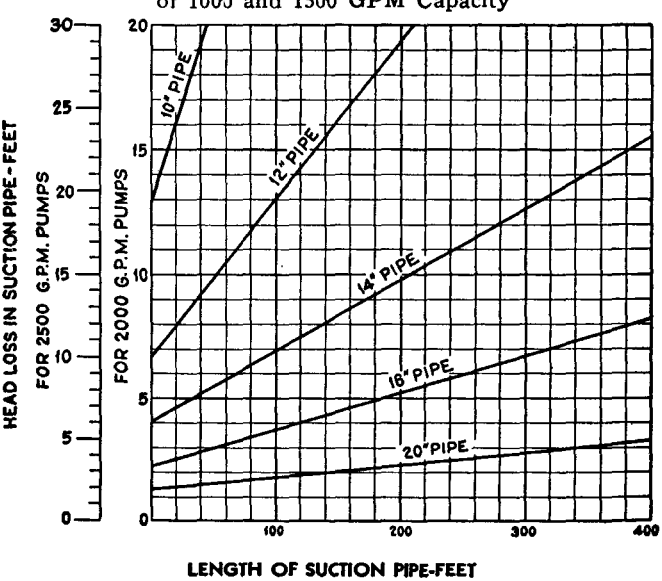

Fig. 114a–3
Chart for Determining Size of Suction Pipe on Pumps of 2000 and 2500 GPM Capacity

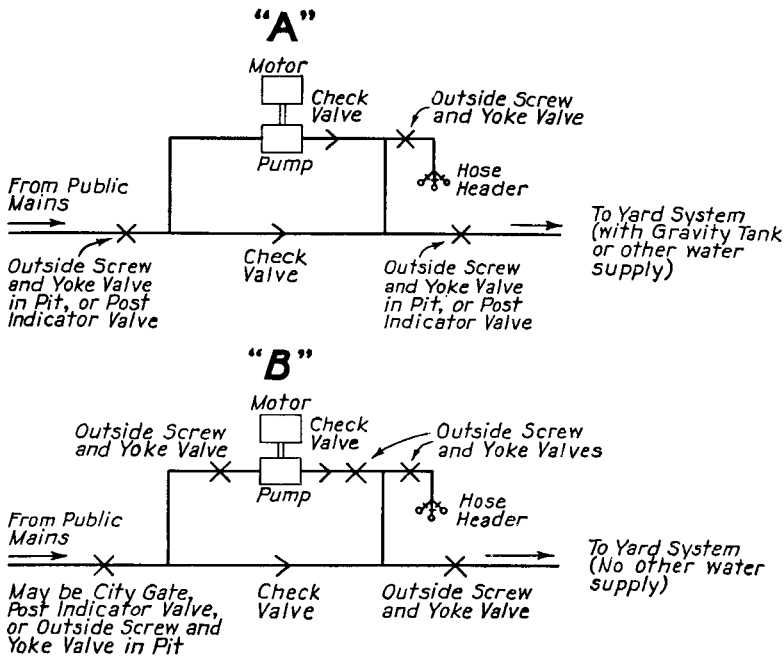

Fig. 114e

Suggested Arrangement of Booster Pump in By-Pass

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

(e) When the suction supply is under sufficient pressure to be of material value without the pump, the pump should be installed in a by-pass. See Fig. 114e.

(f) Suction pipes involving a lift must be carefully laid to avoid air leaks and air pockets, either of which may seriously affect the operation of the pump. Lay a suction pipe involving a lift so that it will have a constantly ascending grade from the water supply to the pump (Fig. 114f).

(g) Lay suction pipe below the frost line. Pay special attention where pipe enters streams, ponds, or reservoirs to prevent freezing either underground or under water (Fig. 6b). Avoid horizontal elbows near the pump (Fig. 114f).

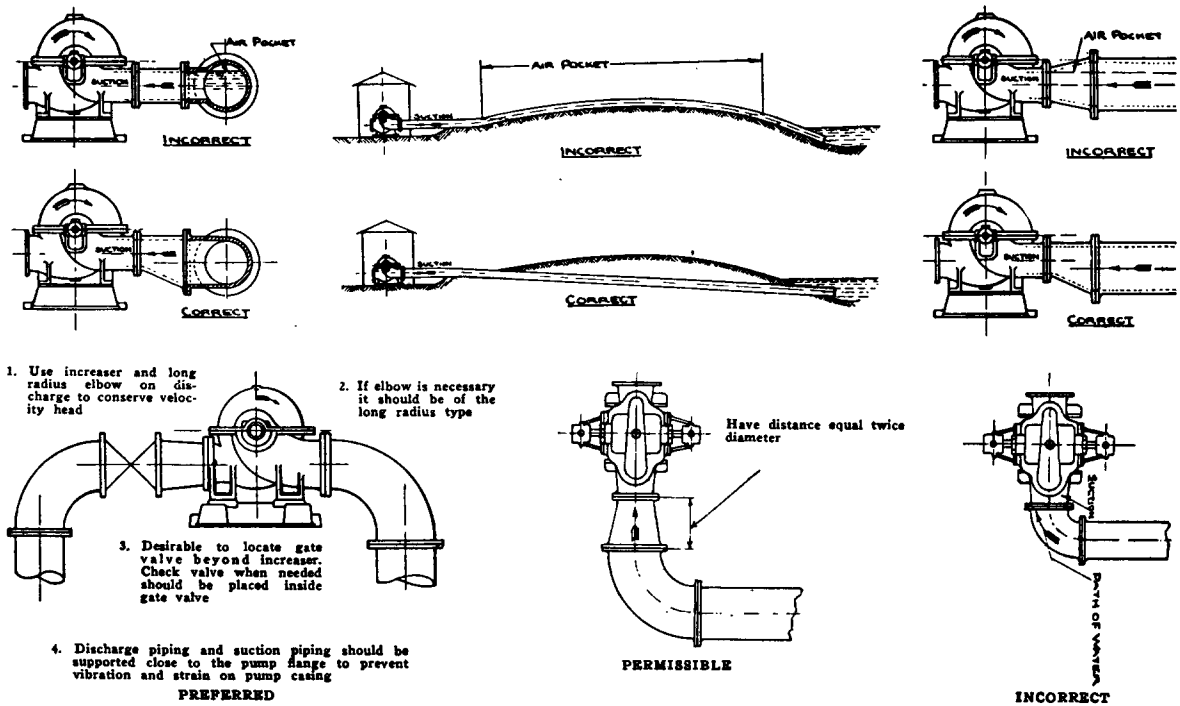

Fig. 114f. Correct and Incorrect Pump Suctions.

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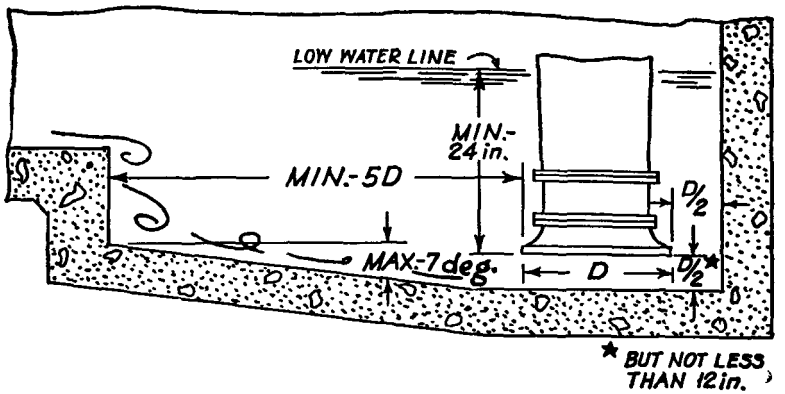


Fig. 114 1

Satisfactory Sump Design

(h) All pump suction pipe, except short lengths between above-ground suction tanks and pumps, should be hydrostatically tested in accordance with the tests for yard mains given in the Standards for Outside Protection, before back filling.

(i) When the suction pipe and pump suction connection are not of the same size, connect them with an eccentric tapered reducer in such a way as to avoid air pockets (Fig. 114f).

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

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

(l) Suction inlets should be at least 24 inches below minimum water level to prevent pumps from drafting air, and at least 12 inches above the bottom of sump or suction well to avoid obstruction. See Fig. 6b and Fig. 114 l.

(m) Provide double removable intake screens (Fig. 6b) having an effective net area of openings below minimum water level of one square inch for each gallon per minute of 150 per cent of rated pump capacity at suction intakes where it is necessary to prevent the passage of materials which might clog the pump. Screens should be so arranged that they can be cleaned or repaired without disturbing the suction pipe. A brass or copper wire screen of one-half inch mesh and No. 10 B. & S. gage wire, secured to a metal frame sliding vertically at the entrance to the intake, makes a serviceable arrangement, and permits ready cleaning and overhauling. The overall area of this particular screen is 1.6 times the net screen opening area. In some localities, suction supply for fire pumps from public water mains may require the installation of an approved strainer to prevent foreign material from passing through the pump into the system piping.

115. DISCHARGE PIPE.

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

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

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

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

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

116. PRIMING SUPPLIES.

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

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

Where the pump is automatically started or provision is made for remote manual starting, the preferred arrangement is a submerged pump (see Fig. 201), but if priming is needed the priming supply should be of a type which will keep the pump primed at all times. No priming method should be selected which will permit contamination of a potable water supply.

The following priming methods are recommended:

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

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

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

The priming tank should be connected to the discharge side of the pump at a point which will insure that all priming water enters the pump and suction pipe, and is not wasted in the discharge pipe of the pump (Fig. 6b). This connection should be 2 inches in diameter irrespective of the size of pump, and include an approved O. S. & Y. gate valve and an approved check valve.

(b) A connection to a domestic water system (when permitted by health regulations). Install approved check and O. S. & Y. gate valves in the priming pipe near the pump.

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

(d) An Exhauster or Siphon Ejector. Where a reliable steam supply or separate water supply under good pressure is available, an exhauster or siphon ejector may be connected between the pump and discharge check valve to exhaust the air from the pump and the suction pipe (Fig. 6b). An approved O. S. & Y. gate valve should be placed in the exhauster connection, to be closed as soon as the pump is primed. Note auxiliary exhaust connection on pump casing in Fig. 6b.

(e) A Mechanically-Operated Exhauster Driven by a Separate Motor. The exhauster should be connected between pump and discharge check valve, so as to completely fill suction pipe and pump (Fig. 6b). An approved O. S. & Y. gate valve should be placed in the exhauster connection, to be closed as soon as pump is primed.

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

The volume required for the priming tank can be readily computed by taking 3 times the quantities given under 116a.

The tank should be connected to the pump as covered in (a) of this article with the connecting pipe not smaller than given in the following table:

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

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

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

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

117. Relief Valve. (a) Pumps connected to adjustable-speed drivers shall be equipped with an approved relief valve. Where pumps are driven by constant-speed motors and the shut-off pressure plus the static suction pressure exceeds 150 pounds, relief valves may be required by the authority having jurisdiction. For pumps supplying standpipe systems only, relief valves will not generally be needed.

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

(c) The relief valve should discharge into an open pipe in plain sight near the pump or into a cone or funnel secured to the outlet of the valve. This cone should be so constructed that the pump operator can easily see

any water wasting through the relief valve, and it should be so made as to avoid splashing water into the pump room. The cone should be piped to a point where water can be freely wasted, preferably outside the building.

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, inches	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.

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

(d) When 2 hose valves are required, use 4-inch pipe between the detachable hose header and the connection to the discharge pipe; when 3 or 4 are required use 6-inch pipe; when 6 or 8 are required use 8-inch pipe. When this pipe is over 15 feet long increase one pipe size.

119. 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.

120. 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.

121. AUTOMATIC AIR RELEASE. Pumps which are automatically controlled shall be provided with a reliable ½-inch float operated air release or equivalent valve to automatically release air from the pump.

122. 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.

SUMMARY OF PUMP DATA

Size of Pump gpm	Size of Discharge Pipe, ins. See 115a	Size of Relief Valve, ins. See 117e	Size of Relief Waste, ins. See 117f	Number Hose Valves See 118b	Size of Test Valve, Ins. See 119
500	6	3	5	2	1¼
750	8	3½	6	3	1½
1000	8	4	8	4	2
1500	10	5	8	6	2½
2000	10	6	10	6	2½
2500	12	6	10	8	2½

VERTICAL SHAFT TURBINE-TYPE PUMPS.

201. 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.

202. 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.

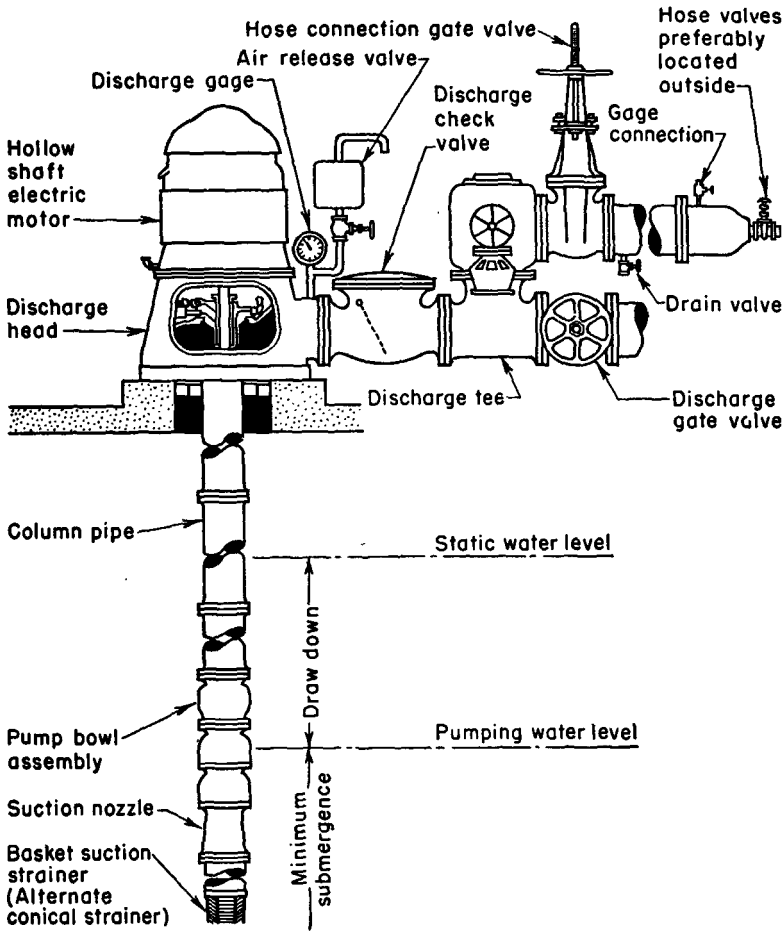


Fig. 201. Vertical Shaft Turbine-Type Pump Installation.

210. Water Supply.

211. 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.

212. 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.

213. WELL CONSTRUCTION.

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

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

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

(d) 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 212(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.

214. 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.

215. 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.

220. Pump.

221. DISCHARGE HEAD.

The discharge head should be of the aboveground type. (See Fig. 201.) 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.

222. PUMP COLUMN.

(a) The column shall be furnished in interchangeable sections not exceeding 10 feet in length and shall be of the flange type. All column flange faces must be parallel and must be machined for rabbet fit to permit accurate alignment.

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

(c) If the pump is to be of the enclosed lineshaft oil lubricated type the shaft enclosing tube shall be furnished in interchangeable sections not over 10 feet in length, of extra strong pipe. An automatic sight feed oiler and solenoid valve energized from the motor circuit shall be provided on a suitable mounting bracket with connection to the shaft tube for oil lubricated pumps.

223. BOWL ASSEMBLY.

(a) The pump bowl shall be of close-grained cast iron or bronze, and provided with bronze wearing rings.

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

224. SUCTION STRAINER.

(a) A cast or heavy fabricated type of non-ferrous cone or basket type strainer shall be attached to the suction manifold of the pump. The suction strainer shall have a free area of at least four times the area of

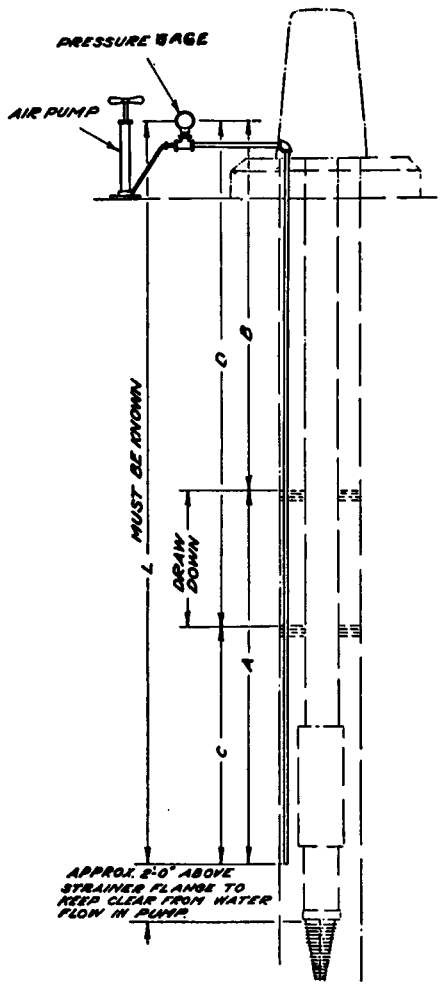


Fig. 225. Air Line Method of Determining Depth of Water Level.

the suction connections and the openings shall be of such size to restrict the passage of a ½ in. sphere.

(b) This suction strainer shall be required in addition to intake screen, specified under paragraph 114 (m).

225. FITTINGS.

(a) The following fittings to be furnished by the pump manufacturer shall be required for attachment to the pump.

Discharge tee or elbow.
Hose valve head (separable type).
Blind flange.
Hose valves.
Automatic air release valve and fittings (See Fig. 201).
Discharge gauge of approved type, reading to 250 pounds.
Relief valve and discharge cone (when required by Section 117).
Water level testing device.

(b) The above fittings with the exception of the automatic air release and water level testing device are subject to same standards as for horizontal fire pumps, Sections 118 to 120 inclusive.

(c) A 1½-inch or larger automatic air release valve is required to vent air from the column and discharge head upon starting the pump and also to serve to admit air to the column to dissipate the vacuum when the pump is stopped.

(d) Each pump installed in a well must be equipped with a suitable water level detector. The air line method (Fig. 225) is considered as a satisfactory method of determining depth of water level. This device should be permanently installed.

A satisfactory method of determining the water level involves the use of an air line of small pipe or tubing and of known vertical length, a pressure or depth gauge, and an ordinary bicycle or automobile pump installed as shown by Fig. 225. The air line pipe should be of known length and extend beyond the lowest anticipated water level in the well in order to assure more reliable gauge readings and should be properly installed. As noted in Fig. 225 an air pressure gauge is used to indicate the pressure in the air line.

The air line pipe is lowered into the well, a tee is placed in the line above the ground, and a pressure gauge is screwed into one connection and the other is fitted with an ordinary bicycle valve to which a bicycle pump is attached. All joints must be made carefully and must be air tight to obtain correct information. When air is forced into the line by means of the bicycle pump the gauge pressure increases until all the water has been expelled. When this point is reached the gauge reading becomes constant. The maximum maintained air pressure recorded by the gauge is equivalent to that necessary to support a column of water of the same height as that forced out of the air line. The length of this water column is equal to the amount of air line submerged.

Deducting this pressure converted to feet (lbs. pressure $\times$ 2.31 = ft.) from the known length of the air line will give the amount of submergence.

The following examples will serve to clarify the above explanation.

Assume a length (L) of 50 ft.

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

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

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

(a) D — B = 31.5 — 26.9 = 4.6 ft.

(b) A — C = 23.1 — 18.5 = 4.6 ft.

(c) $p_1 - p_2 = 10 - 8 = 2$ psi.
$= 2 \times 2.31 = 4.6$ ft.

230. Installation.

231. PUMP HOUSE.

The pump house should be of such character as will offer the minimum obstruction to the convenient handling and hoisting of vertical pump parts. Otherwise the same standard as for horizontal fire pumps should apply. See paragraphs 111 (a) to (f) inclusive.

232. OUTDOOR SETTING.

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

233. FOUNDATION.

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

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

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

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

234. METHOD OF ERECTING.

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

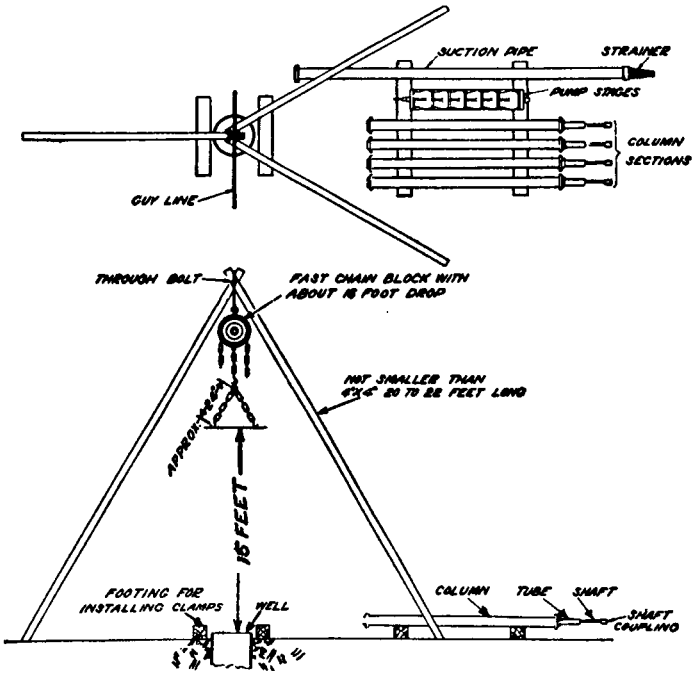


Fig. 234b-1. General Installation Drawing.

(b) The following simple method is the most common.

1. Construct a tripod or portable derrick and use two sets of installing clamps over open well or pump house. After the derrick is in place the alignment should be checked carefully with the well or suction pit to avoid any trouble when setting the pump.
2. Attach set of clamps to the suction pipe on which strainer has already been placed and lower into the well until clamps rest on block beside well casing or on pump foundation.
3. Attach clamps to pump stage assembly and bring over well and install pump stages to suction pipe, etc., until each piece has been installed in accordance with manufacturer's instructions.

235. SETTING IMPELLERS. The setting of the impellers should only be undertaken by a representative of the pump manufacturer. Improper setting will develop excessive friction loss by rubbing of impellers on pump seals with resultant increase in power demand. If adjusted too high there will be a loss in capacity; full capacity is vital for fire pump service. The top shaft nut should be locked or pinned after proper setting.

240. Driver.

(a) The pump may be driven by a vertical hollow shaft electric motor or right angle gear drive with internal combustion engine or steam turbine

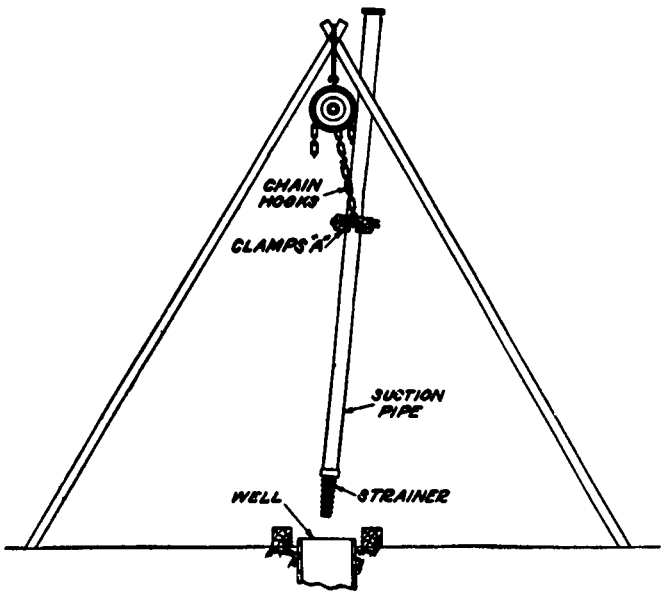


Fig. 234b-2. Suction Pipe Installation.

and having locked rotor current not exceeding the values given in the table in Section 404(a). The speed of the pump should not exceed 1,800 r.p.m. under any conditions. The driver provided must be so constructed that the total thrust of the pump, which includes the weight of the shaft, impellers, and the hydraulic thrust, can be carried on a thrust bearing of ample capacity so that it will have an average life rating of five-year continuous operation. All drivers must be so constructed that axial adjustment of impellers can be made to permit proper installation and operation of the equipment.

(b) Motors shall be direct connected, of the vertical, hollow shaft type, drip proof, normal starting torque, low starting current, squirrel cage induction type, suitable for full voltage starting. The motor shall be designed for a temperature rise not exceeding 40° C. and be of such a capacity that at rated voltage, 115 per cent of its full load ampere rating will not be exceeded under any condition of pump operation. The pump manufacturer shall be responsible for a motor of ample size to drive the unit under any pump load. The motor shall be equipped with an anti-reverse ratchet.

(c) Gear drives must be acceptable to the authority having jurisdiction. Gear drives shall be of the hollow shaft type, permitting adjustment of the impellers for proper installation and operation of the equipment.

(d) Where internal combustion engines under manual control are used, it shall be the pump manufacturer's responsibility to furnish a coupling

of suitable design which will prevent undue strain on either the engine or pump by reverse operation. Automatic starters are equipped with an anti-dieseling device which serves to prevent reverse operation from self ignition during compression.

(e) If dual drive is used all equipment shall be of approved type.

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

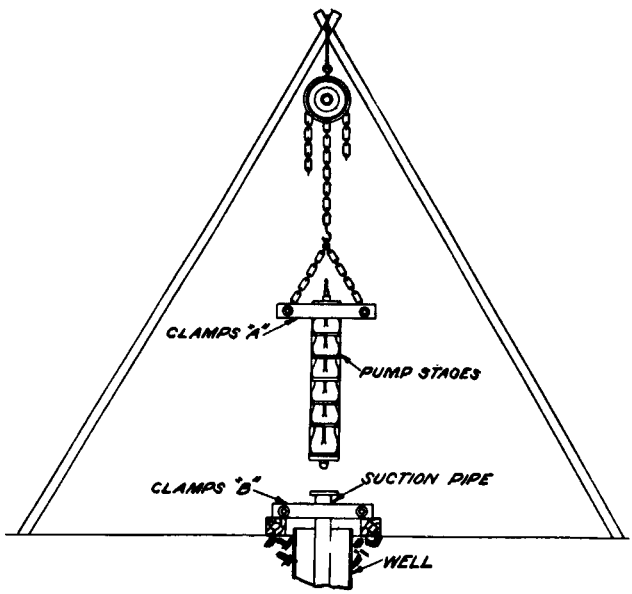


Fig. 234b-3. Installation of Pump Stages.

250. Tests.

251. SHOP TEST.

(a) Before shipment each pump shall be shop tested for performance and strength. The hydrostatic pressure test shall be twice the pressure at rated capacity but never less than 250 p.s.i. Both the discharge casting and pump bowl assembly shall be tested.

(b) All gear drives must be operated at the factory under full load before shipment and must operate without excessive noise or heating during the test.

(c) Charts showing head-delivery, efficiency and brake horsepower curves shall be furnished by the manufacturer. These curves shall be derived from a shop test of the pump and shall be sent to the purchaser promptly after tests, and upon request to the authority having jurisdiction.

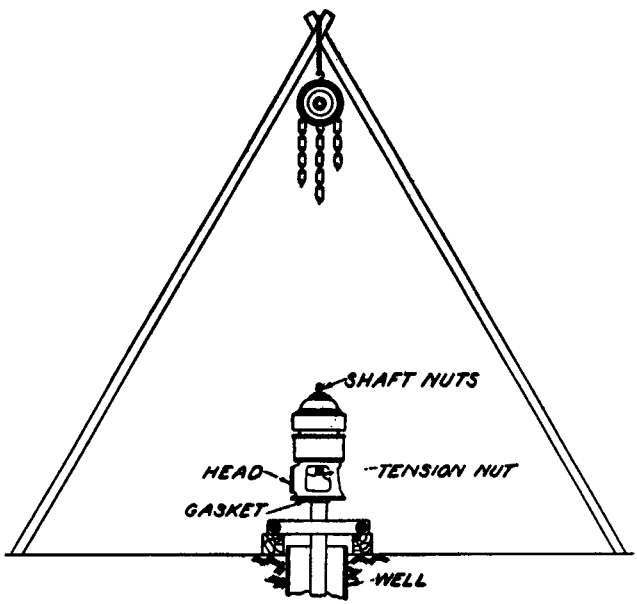


Fig. 234b-4. Installation Diagram—Top Section (Flange Type).

252. FIELD ACCEPTANCE AND SUBSEQUENT TESTS.

(a) When the installation is completed, with wells and pumping equipment all in place, and necessary adjustments and connections made, an operating test shall be made in the presence of the customer, pump manufacturer and representative of the authority having jurisdiction. Rules regarding field acceptance tests in Section 901 should be followed insofar as they apply, excepting that for well installations the test shall include a continuous run for eight hours with discharge at 150 per cent rated capacity at 65 per cent of rated pressure.

(b) A yearly inspection and test at 150 per cent rating to determine pumping water level and condition of pump should be made.

260. Operation and Maintenance.

261. OPERATING.

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

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

262. VIBRATION.

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

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

263. EXCESSIVE MOTOR TEMPERATURE.

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

264. REPAIR.

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

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

SPECIAL FIRE SERVICE PUMPS.

301. Application.

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

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

302. Standard Sizes.

The standard sizes of special fire service pumps have nominal capacities of 200, 300 and 450 gallons per minute with pressure boosts ranging from 40 to 100 pounds per square inch. The pumps shall have such performance characteristics that the power required of the driving motor will not exceed 30 horsepower at any rate of water delivery within the delivery range shown by the head-delivery curve of the pump.

303. Selection of Pump.

Selection of a pump for a given condition should be based on the capacity and pressure conditions in the supply mains as determined by test, and the capacity and pressure requirements of the installation. The pump chosen should be one which has a capacity and pressure rating not less than required without exceeding the capacity limit of the supply main. Where a characteristic curve is not available it should be assumed that the pump may have a maximum suction demand of 130 per cent of its capacity.

304. Pump Requirements.

The pumps shall be specifically approved for fire service. They should be of the horizontally-split case type. They shall have such performance characteristics that, at zero lift, the maximum capacity will not exceed 130 per cent of the rated capacity. The casing shall be designed to withstand hydrostatic pressure of at least 250 pounds per square inch.

305. Installation.

Installation of pumps shall conform to the applicable provisions of sections 111, 112, 113, 114 and 115. See particularly paragraphs 111 (a), (e) and (f), 112 (a) and (b), and 113 (e), and 115 (a), (b) and (c).

306. Attachments.

(a) Two pressure gauges shall be provided, one attached on the discharge and one on the suction side of the pump.

(b) A 4-inch discharge fitting with valved outlet for attachment of 2½-inch hose shall be provided for testing purposes.

(c) Means shall be provided for automatic release of air from the pump and for circulation of sufficient water to prevent the pump from overheating. A ¾-inch air release valve, and a ¾-inch pressure relief valve set slightly below the shut-off pressure, are recommended.

307. Motors.

(a) Motors shall be of such capacity that at rated voltage (and for a-c motors at rated frequency) their full load ampere rating will not be exceeded under any conditions of pump load. It shall be the pump manufacturer's responsibility to provide a motor of ample size to drive the pump.

(b) Motors and their power supply shall conform to the applicable provisions of sections 400, 401, 402, 403 and 404. See particularly paragraphs 400 (a) and (b), 402 (a), (b) and (c), and 404 (a), (c), (d), (e), (f), (g), (h) and (j).

308. Shop Test.

The pump and motor shall be tested in the shop of the pump manufacturer, as a unit, and performance curves showing the head-delivery, efficiency and brake horsepower of the pump shall be furnished to the purchaser promptly after the test and, upon request, to the authority having jurisdiction.

309. Purchase Contract.

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

ELECTRICAL DRIVING AND CONTROL OF PUMPS.

400. 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.

401. Power Station.

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

(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.

402. 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 422 regarding overcurrent protection for the motor branch circuit conductors.

403. 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.

404. Motors.

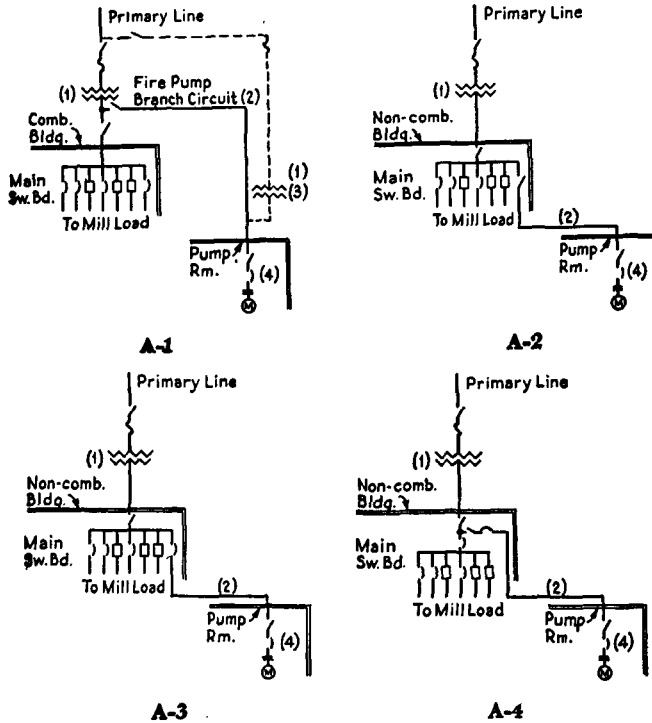
(a) Electric motors are an accepted dependable source of power for operation of centrifugal fire pumps. It is the pump manufacturer's responsibility to provide a motor of ample size as specified in paragraph (b). Only motors wound for 208 volts shall be used for 208 volt services. Direct- or alternating-current 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.

Fig. 402. Typical Examples of Acceptable Fire Pump Electric Supplies.



A—Various Arrangements of Electric Supplies from Public Utility Through Transformers.

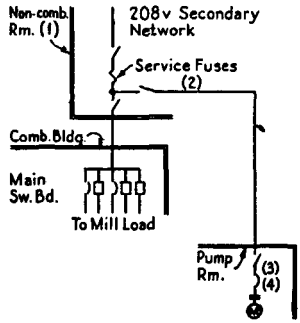
Fig. A — (1) If primary line is overhead, provide lightning protection for the transformers.

(2) Locate fire pump branch circuit so that it will not be damaged by fire in the protected property. In some cases a circuit breaker may be required by authorities having jurisdiction to protect this circuit and prevent a fault causing the primary fuses to blow. See Section 402.

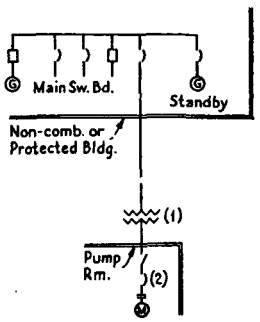
(3) When main plant transformers are large and would require a circuit breaker of high interrupting capacity in the fire pump controller it may be more economical to provide separate transformers for the fire pump, so that a circuit breaker of lower interrupting capacity may be used in the fire pump controller. For a 75 h.p. motor provide at least 75 kva. transformers; for 125 h.p. at least 125 kva.

(4) In some cases where the circuit conditions would permit a circuit breaker of low interrupting capacity, the full load current of the fire pump motor may be high enough to require a circuit breaker which has a higher interrupting capacity. See Section 422.

Fig. 402 (continued)



B—Electric Supply from Underground Utility Company Network.



C—Electric Supply from Generators on Premises.

Fig. B — (1) This room should be accessible in event of fire involving building containing main switchboard so that disconnect switches may be operated to maintain circuit to fire pump motor.

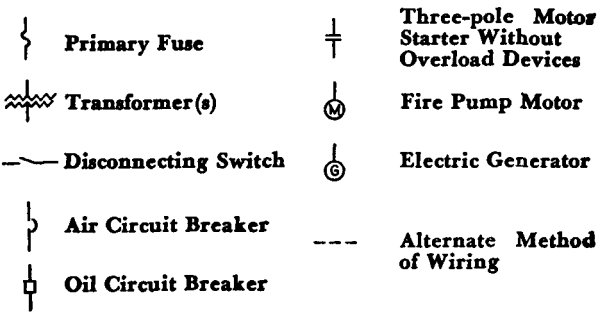
(2) Locate fire pump branch circuit so that it will not be damaged by fire in the protected property. In some cases a circuit breaker may be required by authorities having jurisdiction to protect this circuit and prevent a fault causing the service fuses to blow. See Section 422.

(3) Interrupting capacity of this circuit breaker must be obtained from the utility company.

(4) In some cases where the circuit conditions would permit a circuit breaker of low interrupting capacity, the full load current of the fire pump motor may be high enough to require a circuit breaker which has a higher interrupting capacity. See Section 422.

Fig. C — (1) If fire pump branch circuit is overhead, provide lightning protection. For 75 h.p. motor provide at least 75 kva. transformers; for 125 h.p. at least 125 kva.

(2) In some cases where the circuit conditions would permit a circuit breaker of low interrupting capacity, the full load current of the fire pump motor may be high enough to require a circuit breaker which has a higher interrupting capacity. See Section 422.



The locked-rotor current of three-phase, constant-speed, induction motors, measured with rated voltage and frequency impressed with rotor locked shall at 220 volts not exceed the following values:

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

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

Voltages above 600 are not recommended for fire-pump service, but where it is impracticable to use low voltage, higher voltages may be accepted by the authority having jurisdiction, for motor ratings of approximately 75 h.p. and larger at 2,300 volts and for motor ratings of approximately 100 h.p. and larger at 4,000 volts.

(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. Under such conditions high voltage motors shall be totally enclosed.

(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.

MOTOR CONTROLLERS.

GENERAL REQUIREMENTS FOR ALL CONTROLLERS.

411. 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, but where it is impracticable to use low voltage, higher voltages may be accepted by the authority having jurisdiction. High voltage controllers shall be limited to the automatic type, for full-voltage starting of the motor, and rated at not more than 4,160 volts. (See Sections 441 to 448 inclusive.)

412. Mounting.

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

413. 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.

414. 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 424).

415. 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 422 need not be externally operable.

416. 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.

417. 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.

418. Protection of Auxiliary Circuits.

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

419. Location.

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

(b) A clearance of not less than 2 feet should be provided at the rear of panels designed to be inspected and serviced from the rear.

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

420. 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.

421. 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.

TABLE 422.

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

(See Section 422 for general rule for determining the interrupting capacity of circuit breakers of fire pump controllers.)

Capacity of Transformer Bank kva.	Transformer Secondary Voltage	Length of Fire Pump Branch Circuit Feet	I.C. of Cir. Br. of Fire Pump Controller — Amperes: No branch Cir. Br. (See Fig. 402 A-1 and A-2)	I.C. of Cir. Br. of Fire Pump Controller — Amperes: With branch Cir. Br. (See Fig. 402 A-3 and A-4)
FIRE PUMP MOTORS OF 75 HP. OR LESS				
750	240	50-75	25000	15000
750	240	Over 75	15000	15000
1000	240	50-85	25000	15000
1000	240	Over 85	15000	15000
1500	480	50-75	25000	15000
1500	480	Over 75	15000	15000
1500	240	50-100	25000	15000
1500	240	Over 100	15000	15000
2000	600	25-65	25000	15000
2000	600	Over 65	15000	15000
2000	480	50-85	25000	15000
2000	480	Over 85	15000	15000
2000	240	20-54	50000	25000
2000	240	55-105	25000	15000
2000	240	Over 105	15000	15000
FIRE PUMP MOTORS OF 100 HP. AND 125 HP.				
1000	240	50-110	25000	15000
1000	240	Over 110	15000	15000
1500	480	50-110	25000	15000
1500	480	Over 110	15000	15000
1500	240	25-65	50000	25000
1500	240	66-125	25000	15000
1500	240	Over 125	15000	15000
2000	600	20-55	50000	25000
2000	600	56-135	25000	15000
2000	600	Over 135	15000	15000
2000	480	20-60	50000	25000
2000	480	61-135	25000	15000
2000	480	Over 135	15000	15000
2000	240	30-80	50000	25000
2000	240	81-140	25000	15000
2000	240	Over 140	15000	15000

422. Circuit Breaker.

(a) 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.

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

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

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

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

NOTE: See Section 402(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.

423. 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.

424. 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.

425. 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.

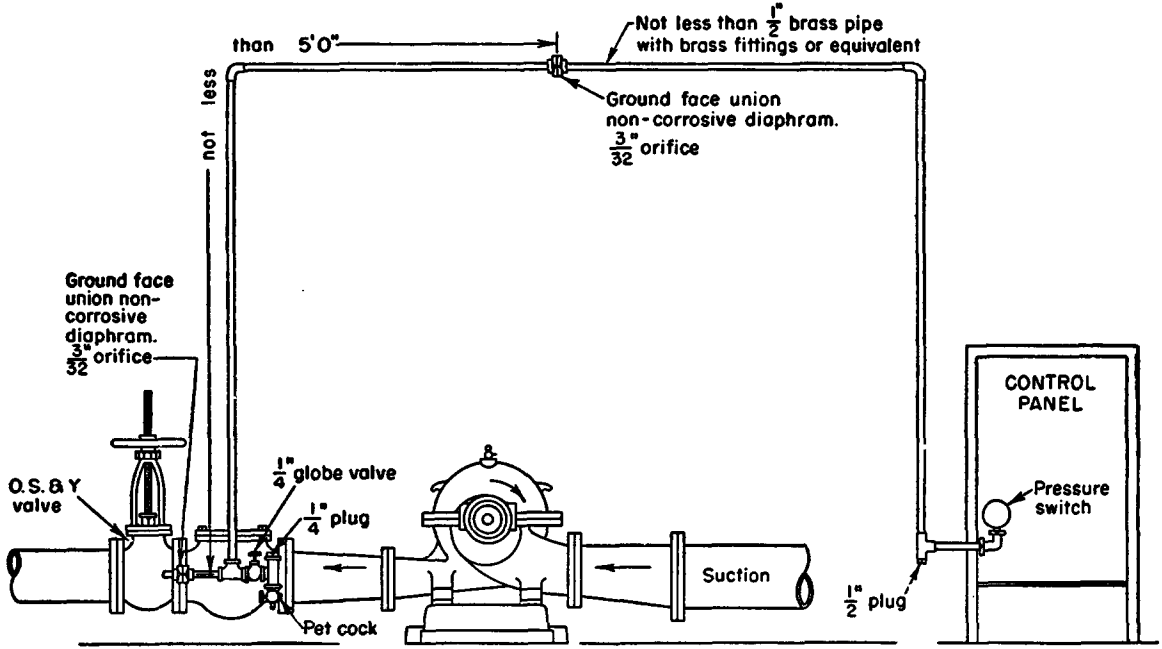


Fig. 431. Piping Connection for Automatic Pressure Switch.

AUTOMATIC TYPE—600 VOLTS AND LESS

431. General.

(a) Control equipment of the automatic type shall comply with the general requirements for all controllers (Sections 411 to 419 inclusive) and with those for non-automatic type (Sections 421, 422, 424 and 425) and, in addition, shall comply with the provisions of the following Sections 432 and 433.

(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.

432. Motor Starter.

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

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

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

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.

(c) 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 423a), independent of the pressure-actuated control switch.

(d) 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.

433. 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.

AUTOMATIC TYPE—FULL VOLTAGE STARTING—IN EXCESS OF 600 VOLTS.

441. Control Equipment.

(a) Where equipment rated in excess of 600 volts is permissible (see Section 411) the control equipment shall comply with the requirements of Sections 431 and 432 except as indicated in Sections 442–448.

442. Provisions for Testing.

(a) The provisions of Section 417 shall not apply, but an ammeter with a suitable transfer switch arranged for reading the current in each phase shall be provided on the controller. An indicating voltmeter with scale calibrated to the high voltage supply and deriving its source of power from the control transformer secondary, shall also be provided on the controller.

443. Disconnecting Under Load.

(a) Provision shall be made to prevent opening the disconnecting means under load.

444. Location of Pressure Actuated Switch.

(a) Special precautions should be taken with regard to the location of the pressure-actuated switch called for in Section 432(b) to prevent any water which may be present due to leakage from coming in contact with high-voltage components.

445. Low Voltage Control Circuit.

(a) The low-voltage control circuit shall be supplied from the high-voltage source through a step-down control-circuit transformer protected by suitable high-voltage fuses. Its voltage shall be interrupted when the main disconnecting means is in the open position.

446. Pilot Lamp.

(a) For these controllers Section 424 shall be replaced by the following:

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

447. Personnel Protection from High Voltage.

(a) The necessary provisions shall be made, including such interlocks as may be needed, to protect the personnel from accidental contact with high voltage.

448. Circuit Breaker.

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

AUTOMATIC CONTROLLERS FOR AUXILIARY BOOSTER AND SPECIAL FIRE SERVICE PUMPS.

551. Application.

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

552. General.

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

553. Mounting.

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

554. Marking.

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

555. Enclosure.

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

556. 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.

557. Conductors and Connections.

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

558. Protection of Auxiliary Circuits.

Auxiliary circuits required by this motor control shall not have overcurrent protective devices connected in them.

559. Location.

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

560. Circuit Breaker.

(a) An automatic circuit breaker, having one pole for each ungrounded conductor shall be provided to isolate the motor control from the line in the event of a short circuit. This circuit breaker shall be approved for disconnect purposes and no further disconnecting device will be required on the control panel. The circuit breaker shall have a continuous rating of at least 115 per cent of the motor full-load current and shall have a current interrupting capacity adequate for the circuit in which it is to be used and not less than 10,000 amperes.

(b) The circuit breaker shall be of an approved type and size which will allow repeated starting at the intervals permitted by the running period timer without tripping, and provide instantaneous short circuit protection. In general the rating of a direct heated thermal element breaker should be the standard rating at or next below 250 per cent of the motor full-load current, but not smaller than 150 per cent, and the rating of an indirect heated thermal element breaker should be the standard rating at or next above 125 per cent of the motor full load current. The circuit breaker shall trip free of the handle and the calibration shall be of the fixed type to discourage adjusting and tampering by unauthorized persons.

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

561. Motor Starter.

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

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

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

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

562. Local Supervision.

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

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

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

563. Controller Wiring.

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

INTERNAL COMBUSTION ENGINE DRIVING OF CENTRIFUGAL FIRE PUMPS.

600. 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 700—Combined Manual and Automatic Controllers for Internal Combustion Engines Driving Centrifugal Fire Pumps.

601. Engines.

(a) Engines shall be specially approved for fire pump service.

(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 coupling 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 suitable 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. The battery shall be an industrial type storage battery with ¼ inch thick positive pasted plates or with tubular filled positive plates, with fully charged specific gravity of 1.200 to 1.220 at 77° F., or equivalent

type of long life heavy duty battery properly selected and applied by the pump manufacturer. Batteries should be furnished in the dry charged condition with electrolyte liquid in a separate container. The electrolyte should be added at the time the unit is put in service.

In lieu of the above a nickel cadmium alkaline type battery may be used where desired.

(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 if suitable alternating current is available, the other should be a selenium rectifier trickle charge unit with a voltmeter, and capable of delivering a current within the range of ½ to 2 per cent of the 8 hour discharge rate in amperes of the battery. The rectifier shall be capable of charging the battery at approximately 25 to 50 per cent of the 8 hour discharge rate. The voltmeter shall have an accuracy of 1 per cent of full scale reading. 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.

602. 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 noncombustible construction of a heavy character and that complete means of drainage and ventilation be provided. Ventilation should be adequate for engine air supply and for removal of hazardous vapors.

(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.

603. 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 lift 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.

605. Fuel Supply for Gasoline Engines.

This system uses a gasoline pump, furnished as a part of the engine, which draws gasoline from the storage tank and delivers it to the carburetor. The gasoline pump should be capable of pumping gasoline at a rate of at least 1½ times the amount needed for the engine while running at rated speed and load. As a supplementary supply there shall also be provided a hand gasoline pump connected to draw gasoline from the storage tank and deliver it to a two quart tank from which the carburetor may be supplied by gravity. See Fig. 605 for a suggested arrangement. This may be modified to suit the conditions, subject to approval by the authority having jurisdiction.

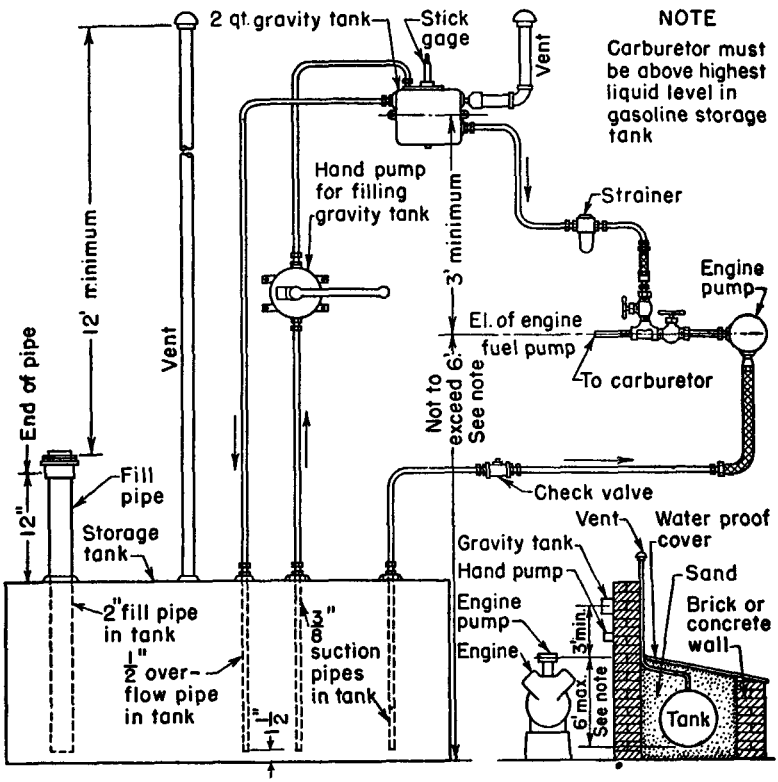


Fig. 605. Fuel System for Gasoline Engine Driving Fire Pump.

Arrangement of gasoline feed is shown schematically. See sections 605 and 607. The valve in the line from the two quart tank to the carburetor is normally kept closed.

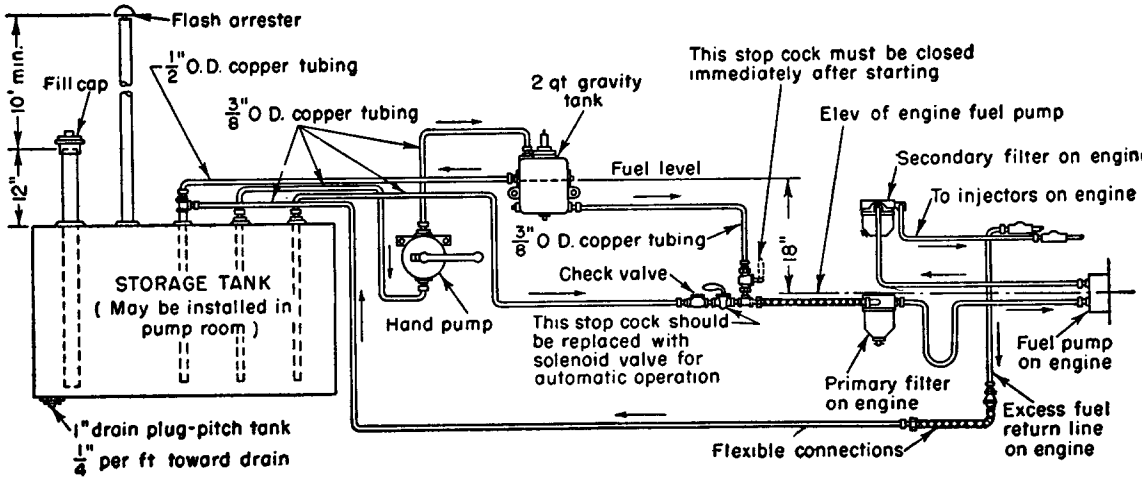


Fig. 606. Fuel System for Diesel Engine Driving Fire Pump.

606. 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 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 the Installation of 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.

Unenclosed inside storage tanks shall not exceed 275 gallons individual or 1,100 gallons aggregate capacity. An oil burner or Diesel engine may be connected to not more than two unenclosed 275 gallon tanks and not more than a total of four such tanks shall be installed in any building. Oil storage tanks in excess of this shall be installed in an enclosure 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 and 6-inch noncombustible liquid tight sills or ramps. Provision shall be made for adequate ventilation of such enclosures prior to entering for inspection or repairs on tanks.

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.

607. Fuel and Exhaust Piping.

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

with soldered screwed joints. Flexible connections shall be of approved metallic type.

(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.

608. 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. The occasional use of an upper lubricant is desirable for smooth operation of the engine and preventing sticking valves.

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

(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.