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NFPA 1911
Service Tests of Pumps on Fire Department Apparatus
1991 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Standards-Making Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NFPA 1911

Standard for
Service Tests of Pumps on Fire Department Apparatus

1991 Edition

This edition of NFPA 1911, *Standard for Service Tests of Pumps on Fire Department Apparatus*, was prepared by the Technical Committee on Fire Department Equipment and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 12-14, 1990 in Miami, FL. It was issued by the Standards Council on January 11, 1991, with an effective date of February 8, 1991, and supersedes all previous editions.

The 1991 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1911

The first edition of NFPA 1911 was issued in 1987 and was titled *Acceptance and Service Tests of Fire Department Pumping Apparatus*. It incorporated much of the material formerly included in the pamphlet *Fire Department Pumper Tests and Fire Stream Tables*, published by the National Board of Fire Underwriters and later the Insurance Services Office. In 1981 all publishing rights were transferred to the NFPA.

This 1991 edition deleted the requirements for acceptance tests of new apparatus from this document as those requirements are now contained in the individual fire apparatus standards. Material previously referenced from other documents was added to make this document self-contained. The requirements were changed to include pumps of 250 gpm (950 L/min) and larger rated at 150 psi (1035 kPa). Requirements were added for an engine speed test, a vacuum test, a pressure control test, a check for the proper operation of the transfer valve, and a check for the accuracy of the gauges and flow meters. The provision allowing testing from a hydrant or other positive pressure source was deleted.

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Standard for

Service Tests of Pumps on Fire Department Apparatus

1991 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates explanatory material on that paragraph in Appendix A.

Information on referenced publications can be found in Chapter 4 and Appendix D.

Chapter 1 Administration

1-1 Scope. This standard shall cover the service testing of fire pumps and attack pumps on fire department automotive apparatus. It does not apply to apparatus equipped solely with pumps rated at less than 250 gpm (950 L/min).

1-2 Purpose. This standard establishes the site, environmental, and equipment requirements for proper testing and the procedures to be followed in performing tests.

1-3* Application. This standard applies to the conduct of in-service tests of fire pumps and attack pumps on fire department apparatus to ensure that the pump continues to be capable of the performance for which it was designed.

1-4 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment, or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Attack Pump. A centrifugal water pump permanently mounted on the apparatus with a rated capacity of 250 gpm (950 L/min) or more but less than 750 gpm (2850 L/min), at 150 psi (1035 kPa) net pump pressure and used for fire fighting.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction." In many circumstances the property owner or his designated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer or departmental official may be the "authority having jurisdiction."

Compound Gauge. A gauge reading pressure from 0 to maximum in lb per sq in. (psi) and vacuum from 0 to 30 in. of mercury (Hg) (100 kPa).

Discharge Pressure. The pressure at the point of gauge attachment on the discharge manifold of the fire pump or attack pump, as determined by the gauge when corrected for any gauge error.

Dynamic Suction Lift. The sum of the vertical lift and the friction and entrance loss due to the flow through the suction strainers and hose, expressed in ft. Divide by 2.31 to get psi.

Fire Pump. A centrifugal water pump permanently mounted on the apparatus with a rated capacity of 750 gpm (2850 L/min) or more at 150 psi (1035 kPa) net pump pressure and used for fire fighting.

Gallons. United States gallons.

GPM. Gallons per minute.

Intake Pressure. The pressure at the point of gauge attachment on the intake passageway of the pump, as determined by the gauge, and corrected for any gauge error.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Lift. The height that water must be raised during a drafting operation, as measured from the surface of a static source of water to the centerline of the pump.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Negative Pressure. Pressure less than atmospheric pressure.

Net Pump Pressure.* The sum of the discharge pressure and the dynamic suction lift converted to psi when pumping at draft, or the difference between the discharge pressure and the intake pressure when pumping from a hydrant or other source of water under positive pressure.

PSI. Pounds pressure per square inch.

PSIG. Gauge pressure in pounds per square inch (pressure above atmospheric pressure).

Service Tests. Tests made after a fire pump or an attack pump has been put into service to determine if its performance is still acceptable.

Shall. Indicates a mandatory requirement.

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

Suction Pressure. See Intake Pressure.

Vacuum. The reduction in atmospheric pressure inside a pump or suction hose. Vacuum is typically expressed in inches of mercury.

Vertical Lift. The vertical distance from the surface of the water to the center of the pump intake.

1-5 Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). The unit "liter" is outside of but recognized by SI and is commonly used in international fire protection. In this standard, values for measurement are followed by an equivalent in SI units, but only the first stated value shall be considered as the requirement, as the value in SI units may be approximate. Table 1-5 shows the actual conversion factors that can be used where SI units are not shown in the text or where more precision is desired.

Table 1-5

1 ft = 0.3048 meters (m)
1 in. = 25.4 millimeters (mm)
1 sq in. = 645.2 sq millimeters (sq mm)
1 gal = 3.785 liters (L)
1 in. of mercury (Hg) = 3.386 kilopascals (kPa)
1 in. of mercury (Hg) = .0340 bar
1 psi = 6.895 kilopascals (kPa)
1 psi = .0690 bar
1 gal per min = 3.785 liters per min (L/min)
1 gal per min = 0.833 imperial gal per min

Chapter 2 Equipment and Site Requirements

2-1* Test Site. The test site shall be adjacent to a supply of clear water at least 4 ft (1.2 m) deep, with the water level not more than 10 ft (3 m) below the center of the pump intake and close enough to allow the suction strainer to be submerged at least 2 ft (0.6 m) below the surface of the water when connected to the pump by 20 ft (6 m) of suction hose.

2-2* Environmental Conditions. Pump tests shall be performed when conditions are as follows:

Air temperature:	0° to 100°F (−18° to 38°C)
Water temperature:	35° to 90°F (2° to 32°C)
Barometric pressure:	(corrected to sea level) 29 in. Hg (98.2 kPa), minimum

2-3 Equipment.

2-3.1 Suction Hose and Strainer. When testing a pump, 20 ft (6.1 m) of suction hose of the appropriate size for the rated capacity of the pump as shown in Table 2-3.1(a) shall be used. A suction strainer that will allow flow with total friction and entrance loss not greater than specified in Table 2-3.1(b) shall be furnished.

Table 2-3.1(a)

Rated Capacity (gpm)	Suction Hose Size (in.)	No. of Suction Lines	Maximum Lift (ft)
250 - 300	3	1	10
350 - 500	4	1	10
600 - 750	4½	1	10
1000	5	1	10
1250	6	1	10
1500	6	1 or 2	10
1750	6	2	8
2000 - 2500	6	2	6

2-3.2* Discharge Hose. Sufficient fire hose shall be provided to allow discharge of rated capacity to the nozzles or other flow-measuring equipment without exceeding a flow velocity of 35 ft per sec (10.7 m/sec) (approximately 500 gpm for 2½-in. hose).

2-3.3 Flow-Measuring Equipment.

2-3.3.1* Nozzles. Where nozzles are used for flow measurements, they shall be smoothbore and of a size sufficient for the anticipated flows. Pitot tubes of a type approved by the authority having jurisdiction shall be used to measure the flow. *(See Appendix B, Tables B-1(a), (b), (c), and (d), for information on determination of flow rates with nozzles.)*

2-3.3.2 Other Flow-Measuring Equipment. Other equipment, such as flow meters, volumetric tanks, or weigh tanks, may be used for measuring the flow if approved by the authority having jurisdiction.

2-3.4 Pressure-Measuring Equipment.

2-3.4.1* Intake and discharge pressure gauges used for testing shall be designed to ANSI B40.1, *Gauges—Pressure Indicating Dial Type—Elastic Element*, Grade A, and shall be at least size 3½ per ANSI B40.1, Figure 6. The intake gauge shall have a range of 0 to 30 in. Hg vacuum (0 to −100 kPa). The discharge gauge shall have a range of 0 to 400 psig (0 to 2500 kPa). The intake gauge may consist of a mercury manometer.

2-3.4.2 Pitot gauges used for testing shall be designed to ANSI B40.1, *Gauges—Pressure Indicating Dial Type—Elastic Element*, Grade A, and shall be at least size 2½ per ANSI

Table 2-3.1(b) Friction and Entrance Loss in 20 ft (6 m) of Suction Hose, Including Strainer

Flow Rate gpm	Suction Hose Size (Inside Diameter) 3 in.		$3\frac{1}{2}$ in.		4 in.		$4\frac{1}{2}$ in.		5 in.		6 in.		2 — $4\frac{1}{2}$ in.		2 — 5 in.		2 — 6 in.	
	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg	ft water	in. Hg
250	5.2 (1.2)	4.6																
175	2.6 (0.6)	2.3																
125	1.4 (0.3)	1.2																
300	7.5 (1.7)	6.6	3.5 (0.8)	3.1														
210	3.8 (0.8)	3.4	1.8 (0.4)	1.6														
150	1.9 (0.4)	1.7	0.9 (0.2)	0.8														
350			4.8 (1.1)	4.2	2.5 (0.7)	2.1												
245			2.4 (0.5)	2.1	1.2 (0.3)	1.1												
175			1.2 (0.3)	1.1	0.7 (0.1)	0.6												
450					4.1 (1.0)	3.6	2.7 (0.4)	2.6										
315					2.0 (0.5)	1.8	1.2 (0.2)	1.1										
225					1.0 (0.2)	0.9	0.6 (0.1)	0.5										
500					5.0 (1.3)	4.4	3.6 (0.8)	3.2										
350					2.5 (0.7)	2.1	1.8 (0.4)	1.6										
250					1.3 (0.4)	1.1	0.9 (0.3)	0.8										
600					7.2 (1.8)	6.4	5.3 (1.0)	4.7	3.1 (0.6)	2.7								
420					3.5 (1.0)	3.1	2.5 (0.5)	2.2	1.6 (0.3)	1.4								
300					1.8 (0.4)	1.6	1.3 (0.2)	1.0	0.6 (0.1)	0.5								
700					9.7 (2.7)	8.6	7.3 (1.3)	6.4	4.3 (0.8)	3.8								
490					4.9 (1.1)	4.3	3.5 (0.7)	3.1	2.0 (0.4)	1.8								
350					2.5 (0.7)	2.2	1.6 (0.3)	1.4	0.9 (0.2)	0.8								
750					11.4 (2.9)	9.8	8.0 (1.6)	7.1	4.7 (0.9)	4.2	1.9 (0.4)	1.7						
525					5.5 (1.5)	4.9	3.9 (0.8)	3.4	2.3 (0.5)	2.0	0.9 (0.2)	0.8						
375					2.8 (0.7)	2.5	2.0 (0.4)	1.8	1.2 (0.2)	1.1	0.5 (0.1)	0.5						
1000							14.5 (2.8)	12.5	8.4 (1.6)	7.4	3.4 (0.6)	3.0						
700							7.0 (1.4)	6.2	4.1 (0.8)	3.7	1.7 (0.3)	1.5						
500							3.6 (0.8)	3.2	2.1 (0.4)	1.9	0.9 (0.2)	0.8						
1250									13.0 (2.4)	11.5	5.2 (0.9)	4.7	5.5 (1.2)	4.9				
875									6.5 (1.2)	5.7	2.6 (0.5)	2.3	2.8 (0.7)	2.5				
625									3.3 (0.7)	2.9	1.3 (0.3)	1.1	1.4 (0.3)	1.2				
1500											7.6 (1.4)	6.7	8.0 (1.6)	7.1	4.7 (0.9)	4.2	1.9 (0.4)	1.7
1050											3.7 (0.7)	3.3	3.9 (0.8)	3.4	2.3 (0.5)	2.0	0.9 (0.3)	0.8
750											1.9 (0.4)	1.7	2.0 (0.4)	1.8	1.2 (0.2)	1.1	0.5 (0.1)	0.5
1750											10.4 (1.8)	9.3	11.0 (2.2)	9.7	6.5 (1.2)	5.7	2.6 (0.5)	2.3
1225											5.0 (0.9)	4.6	5.3 (1.1)	4.7	3.1 (0.7)	2.7	1.2 (0.3)	1.1
875											2.6 (0.5)	2.3	2.8 (0.6)	2.5	1.6 (0.3)	1.4	0.7 (0.2)	0.6
2000													14.5 (2.8)	12.5	8.4 (1.6)	7.4	3.4 (0.6)	3.0
1400													7.0 (1.4)	6.2	4.1 (0.8)	3.7	1.7 (0.3)	1.5
1000													3.6 (0.8)	3.2	2.1 (0.4)	1.9	0.9 (0.2)	0.8
2250															10.8 (2.2)	9.5	4.3 (0.8)	3.8
1575															5.3 (1.1)	4.7	2.2 (0.4)	1.9
1125															2.8 (0.5)	2.5	1.1 (0.2)	1.0
2500															13.0 (2.4)	11.5	5.2 (0.9)	4.7
1750															6.5 (1.2)	5.7	2.6 (0.5)	2.3
1250															3.3 (0.7)	2.9	1.3 (0.3)	1.1

NOTE: Figures in parentheses indicate increment to be added or subtracted for each 10 ft of hose less than or greater than 20 ft.

B40.1, Figure 6, with a range sufficient to have the anticipated pressures within the middle third of the dial (*see A-2-3.4.1*).

2-3.4.3 All gauges shall have been calibrated within the week preceding the tests. Calibrating equipment shall consist of a dead weight gauge tester or a master gauge meeting ANSI B40.1, *Gauges—Pressure Indicating Dial Type—Elastic Element*, Grade 3A or 4A, that has been calibrated by its manufacturer within the preceding year.

2-3.4.4 All gauge connections to the pump shall include "snubbing" means, such as a needle valve, that can be used to damp out rapid gauge needle movements unless the gauges are liquid filled.

2-3.5 Speed-measuring equipment shall consist of either a tachometer, measuring revolutions per minute, or a revolution counter and stopwatch used on a checking shaft outlet. When a tachometer is used, it shall be of a type approved by the authority having jurisdiction. When a revolution counter and stopwatch are used, the stopwatch shall be equipped with a full sweep second hand or shall be of a digital reading type.

2-3.6 Where tests are performed inside a structure or anywhere having limited air circulation, carbon monoxide monitoring equipment shall be used. Such equipment shall be checked and calibrated regularly and shall include a suitable warning device.

Chapter 3 Service Tests

3-1* Frequency. Service tests shall be conducted at least annually and whenever major repairs or modifications to the pump or any component of the apparatus that is used in pump operations have been made.

3-2 Conditions for Test.

3-2.1 Service tests shall be conducted at a site meeting the conditions outlined in Section 2-1 and when the environmental conditions are as defined in Section 2-2. All tests requiring the flowing of water shall be conducted with the pump drafting. If it is impractical to provide all specified conditions, the authority having jurisdiction may authorize tests under other conditions.

3-2.2 Engine driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests. If the chassis engine drives the pump, all headlights, running lights, warning lights, and air conditioner(s), if provided, shall be operating during the pumping portion of this test.

3-3 Procedure.

3-3.1 Engine Speed Check. A check of the no load governed engine speed shall be made. If the engine speed does not equal the no load governed engine speed at the time the apparatus was new, the reason for the discrepancy shall be determined and corrected prior to starting any testing.

3-3.2 Vacuum Test. A vacuum test shall be conducted on the pump. With all intakes capped and all discharge valves closed and uncapped, a vacuum of at least 22 in. Hg (74.5 kPa) shall be developed using the pump priming device. The vacuum shall not drop more than 10 in. Hg (33.9 kPa) in 5 min. The pump priming device shall not be operated once the 5-min test has begun.

3-3.2.1 The maximum vacuum attained may be reduced by 1 in. Hg (3.4 kPa) for each 1000 ft (305 m) of elevation of the test site above 1000 ft (305 m).

3-3.3* Pumping Test. The pump shall be subjected to a pumping test of at least 40 min duration, consisting of at least 20 min pumping rated capacity at 150 psi (1035 kPa) net pump pressure, at least 10 min pumping 70 percent of rated capacity at 200 psi (1380 kPa) net pump pressure, and at least 10 min pumping 50 percent of rated capacity at 250 psi (1725 kPa) net pump pressure. The pump shall not be stopped except when discharges are closed to permit changing hose or nozzle.

3-3.3.1* If the pump is a two-stage parallel/series type pump, the test at 100 percent of capacity shall be run with the pump in parallel mode, the test at 70 percent of capacity may be run with the pump in either series or parallel mode, and the 50 percent of capacity test shall be run with the pump in series mode.

3-3.4* Pressure Control Test. The pressure control device on the pump shall be tested as follows.

(a) The pump shall be operated at draft, delivering rated capacity at 150 psig (1035 kPag) discharge pressure. The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 150 psig (1035 kPag). All discharge valves shall be closed no more rapidly than in 3 sec time and no more slowly than in 10 sec time. The rise in discharge pressure shall not exceed 30 psi (207 kPa).

(b) The original conditions of pumping rated capacity at 150 psig (1035 kPag) discharge pressure shall be reestablished. The discharge pressure shall be reduced to 90 psig (620 kPag) by throttling the engine fuel supply, with no change to the discharge valve setting, hose, or nozzles. The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 90 psig (620 kPag). All discharge valves shall be closed no more rapidly than in 3 sec time and no more slowly than in 10 sec time. The rise in discharge pressure shall not exceed 30 psi (207 kPa).

(c) The pump shall be operated at draft, delivering 50 percent of rated capacity at 250 psig (1725 kPag) discharge pressure. The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 250 psig (1725 kPag). All discharge valves shall be closed no more rapidly than in 3 sec time and no more slowly than in 10 sec time. The rise in discharge pressure shall not exceed 30 psi (207 kPa).

3-3.5* Gauge and Flow Meter Test. Each water pressure gauge or flow meter shall be checked for accuracy. Pressure gauges shall be checked at at least 3 points including 150 psi (1035 kPa), 200 psi (1380 kPa), and 250 psi

(1725 kPa). Any gauge that reads off by more than 10 psi (69 kPa) shall be recalibrated, repaired, or replaced. Flow meters shall be tested at the test flows shown in Table 3-3.5. Any meter that reads off by more than 10 percent shall be recalibrated or repaired.

Table 3-3.5 Flow Measuring Points for Flow Meters

Pipe size in.	mm	Test Flow gpm	L/min
1½	38	120	454
2	51	180	682
2½	65	300	1135
3	76	700	2650
4	100	1000	3785

3-3.6* Other Tests. Other tests shall be conducted at the direction of the authority having jurisdiction.

3-4* Test Results.

3-4.1* The ambient air temperature, water temperature, vertical lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to the pump test. Any significant changes in these conditions during the test should be noted on the test record.

3-4.2* The engine, pump, transmission, and all parts of the apparatus shall exhibit no undue heating, loss of power, overspeed, or other defect during the entire test. The average flow rate, discharge pressure, intake pressure, and engine speed shall be calculated and recorded at the end of each phase of the pumping test and the records placed on file.

3-4.3 Results of other tests shall be satisfactory to the authority having jurisdiction and shall be recorded and placed on file.

3-4.4 Data submitted at the time of the delivery test and all results of service tests shall be maintained in a permanent file so that the condition of the pump can be compared over years of operation.

Chapter 4 Referenced Publications

4-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

4-1.1 ANSI Publication. American National Standards Institute, 1403 Broadway, New York, NY 10018.

ANSI B40.1-1985, *Gauges—Pressure Indicating Dial Type—Elastic Element*

Appendix A

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

A-1-3 Investigation has shown that where regular and systematic tests of pumps are not made, defects often exist and may continue undetected for considerable periods under the light demands at ordinary fires and only become apparent at a large fire where the pump is called on to perform at or near rated capacity. Furthermore, regular tests are valuable training for pump operators in operating pumps at draft. The breakdown of a pump at a fire or the inability of the crew to operate it properly may cause needless loss of life and property.

Environmental concerns and other considerations or circumstances (such as water shortages) should not relieve a fire department from the requirements set forth herein. Where such circumstances make it difficult to comply, alternative means for complying should be found (i.e., drafting pits, etc.)

A-1-4 Net Pump Pressure. When operating from a hydrant the net pump pressure is typically less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psi and the intake (suction) gauge reads 20 psi, the net pump pressure equals 130 psi. When operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge is reading 145 psi and the intake (suction) gauge is reading 10 in. of mercury (Hg), the net pump pressure will be 150 psi (1 in. Hg = .5 psi).

A-2-1 Apparatus should be tested at draft and the vertical lift, i.e., the vertical distance from the surface of the water to the center of the pump intake, should not be more than 10 ft (3 m). It is important that a proper site be selected for the testing.

The site should, if possible, be located along an improved roadway or on solid ground where the water is from 4 to 8 ft (1.2 to 2.4 m) below the grade. It should be possible to reach the water from the pump intake with not more than 20 ft (6 m) of hard suction hose with the strainer submerged at least 2 ft (.6 m) and with no humps in the hose. The water should be at least 4 ft (1.2 m) deep where the strainer is located to provide clearance below the strainer and sufficient depth above it. If drafting from shallow water is necessary, a special basket or container should be used to prevent the action of the water moving into the hose from drawing in particles from the stream bed. Clean fresh water is desirable, but where salt water is drafted, the pump, piping, fittings, and pressure regulating governors should be thoroughly flushed out after testing.

The apparatus should be parked as close as possible to the water's edge. It is usually more convenient to have the pump control panel side away from the water. Front or rear intakes should be avoided, as the piping between the pump and inlet is usually more restrictive than the side intakes.

The size of the suction hose to be used will depend on the altitude and the lift, as well as the rated capacity of the pump to be tested. Chafing pads should be provided to prevent injury to the suction hose when the hose is in contact with sharp edges of docks, manholes, walls, and rocks.

A-2-2 If conditions are not within the limits specified, the test should be delayed until they are satisfactory, or the tests performed and the results confirmed by another test at a later date. It is particularly important that the water supply be nonaerated and not over 90°F (32°C). Otherwise the pump performance may be affected seriously.

A-2-3.2 The discharge hose layout consists of 2½-in. (65-mm) or larger hose lines to one or more smoothbore nozzles of suitable size. The hose performs two functions: carrying the water from the pump to the nozzle and providing enough total friction loss to reduce the pressure from the pump discharge pressure required to the nozzle pressure desired. If only a relatively short length of hose is required to perform the first function, the second function can be performed by increasing friction loss through partially closing the discharge valves on the apparatus.

Discharge hose lines should be securely fastened to the pump outlets to avoid injury to personnel should the hose come loose from the coupling during the test. In most cases a rope hose tool is adequate for this purpose.

The size of nozzle used is usually chosen to give the desired discharge at a nozzle pressure between 60 and 70 psi (414 and 483 kPa). This pressure is neither so high that the pitot is difficult to handle in the stream nor so low that the normal inaccuracies of a gauge used at low pressure would come into play. Nozzle (pitot) pressures less than 50 psi (345 kPa) or higher than 100 psi (690 kPa) should be avoided. The nozzle should always be securely tied; never allow a test to be made while depending on any person(s) to hold the nozzle. Failure to abide by this precaution has caused serious injuries.

For the protection of the operator, wherever possible, the 250-psi (1725-kPa) test should be conducted using the pump discharge outlets on the opposite side of the apparatus from the pump control panel.

Table A-2-3.2 shows suggested hose and nozzle layouts using 2½-in. (65-mm) hose. Where two or more lines are indicated for use with one nozzle, they are to be siamesed into a heavy stream appliance. The hose used should be attack hose as defined by NFPA 1961, *Standard for Fire Hose*, and should have been recently tested in accordance with NFPA 1962, *Standard for the Care, Use, and Maintenance of Fire Hose Including Couplings and Nozzles*. Other layouts with combinations of hose and nozzles are not intended to be precluded from use by these suggested layouts.

Table A-2-3.2 Hose and Nozzle Layout Suggestions

Discharge gpm	
2500	Three 100-ft lines into 2¼-in. nozzle, in duplicate
2250	Three 100-ft lines into 2¼-in. nozzle, in duplicate
2000	Two 100-ft lines into 2-in. nozzle, in duplicate
1750	Two 100-ft lines into 2-in. nozzle, in duplicate
1500	Three 100-ft lines into 2-in. nozzle and one 50-ft line into 1⅜-in. or 1½-in. nozzle
1250	Three 100-ft lines and one 50-ft line into 2 ¼-in. nozzle; or two 100-ft lines, into 1 ¾-in. nozzle and one 50-ft line into 1½-in. nozzle
1000	Two or three 100-ft lines into 2-in. nozzle
600-750	Two 100-ft lines into 1½-in. or 1¾-in. nozzle
400-500	One 50-ft line into 1⅜-in. or 1½-in. nozzle
250-350	One 50-ft line into 1⅛-in. or 1¼-in. nozzle

A-2-3.3.1 Nozzles suitable for testing usually may be found in the regular equipment of a fire department. However, the actual coefficient of discharge of each nozzle should be known; otherwise, test results may be erroneous. The actual coefficient of discharge must be determined by tests conducted by competent persons using equipment such as weigh tanks or calibrated flow meters. Nozzles should be used with portable or mounted monitors. Hand held nozzles should not be used.

Only smoothbore nozzles should be used. Care should be taken that washers or gaskets do not protrude into the nozzle because a perfectly smooth waterway is essential. Nozzle tips from ¾-in. (19-mm) to 2¼-in. (57-mm) inside diameter are desirable for use during various capacity and pressure tests. They should be free of nicks and scratches to ensure a smooth stream. Tips should be measured, preferably after being attached and ready for the test, to ensure that there is no mistake about the size of the tip used.

A pitot tube with air chamber and pressure gauge is necessary for determining the velocity pressure of the water at the nozzle. The pitot tube may be of several suitable types; the type shown in Figure A-2-3.3.1(a) may be readily constructed. It should be connected by brass or other nonferrous metal pipe fittings to an air chamber and pressure gauge as shown in Figure A-2-3.3.1(b). A typical commercially available style is shown in Figure A-2-3.3.1(c). The pitot tube should be kept free of dirt and the air chamber free of water. Any water that accumulates in the air chamber should be removed after each test. The knife edges, indicated in Figure A-2-3.3.1(a), will get battered in service and must be kept sharp to reduce as much spray as possible caused by inserting the pitot into the stream.

To ensure accurate and consistent readings, pitot tubes should be fixed in the proper position. A mechanical device may be desirable to hold the pitot tube rather than holding it by hand [*see Figure A-2-3.3.1(d)*]. The proper position is in the center of the stream with the end of the tube a distance equal to half of the nozzle diameter away from the end of the nozzle.

A-2-3.4.1 It is important that gauges be sufficiently accurate to ensure that test results are reliable. Grade A gauges per ANSI B40.1 must be accurate within 2 percent of the span over the entire scale and within 1 percent over the middle half of the scale. This means that a 0-400 psi (0-2750 kPa) gauge will be accurate within 4 psi (28 kPa) from 100 to 300 psi (690-2070 kPa). Grade 3A or 4A gauges, which are used for calibrating other gauges, must be accurate within 0.25 percent or 0.10 percent, respectively, over the entire span.

While 0-400 psi (0-2750 kPa) is not a preferred range per ANSI B40.1, such gauges are readily available. Graduation increments should be no greater than twice the allowable error in the middle of the scale (8 psi maximum on a 0-400 psi Grade A gauge or 28 kPa maximum on a 0-2750 kPa Grade A gauge), and smaller increments are recommended. Many variations and special constructions are available, and gauge manufacturers may be contacted for their recommendations.

A-3-1 Major repair does not necessarily refer to the length of time that a repair takes but rather whether or not a repair affects a major component of the pump assembly

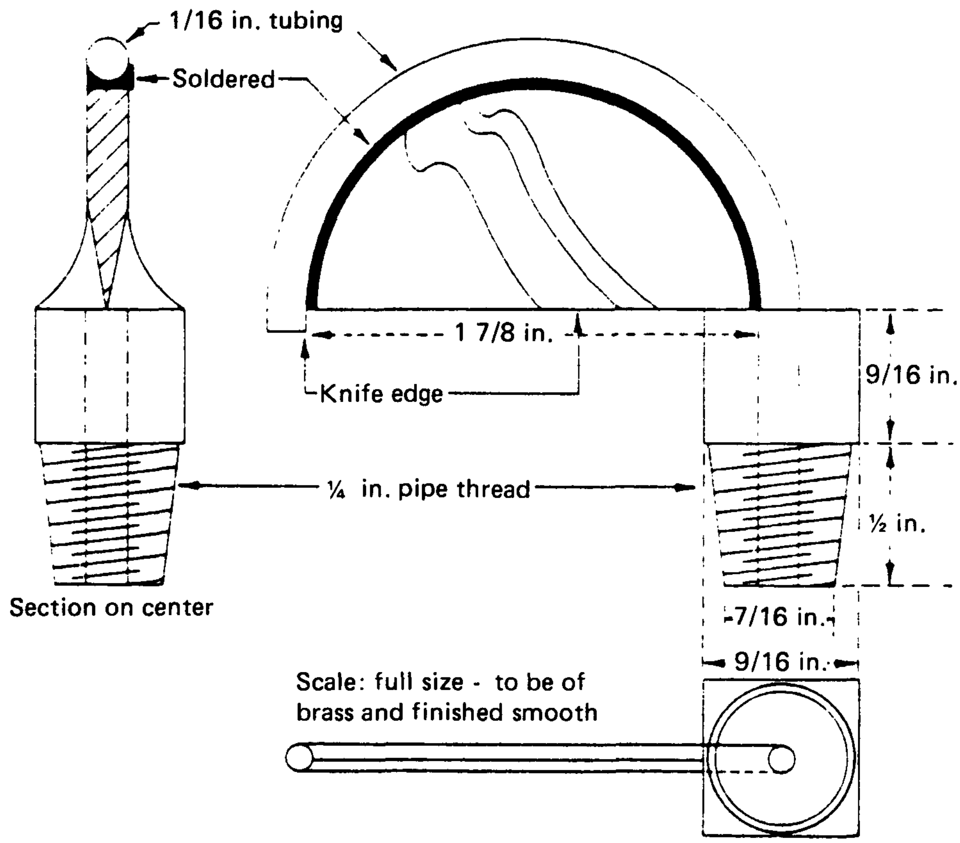

Figure A-2-3.3.1(a) Nozzle stream pitot tube.

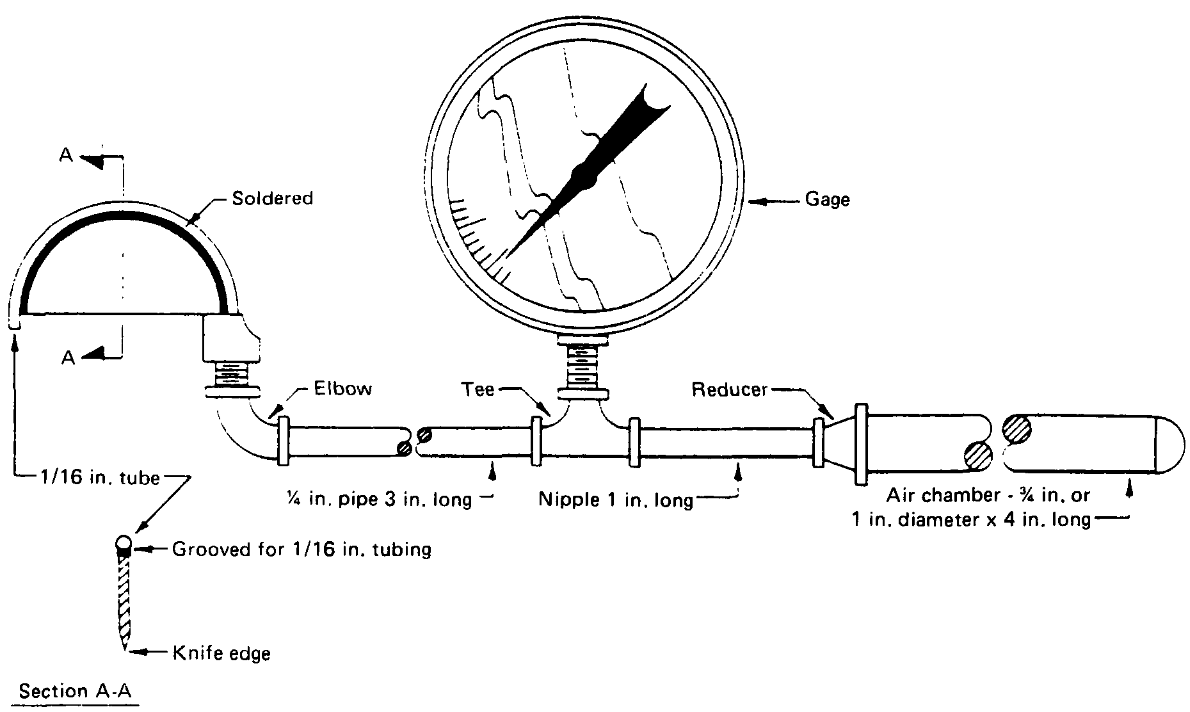

Figure A-2-3.3.1(b) Pitot tube assembly.

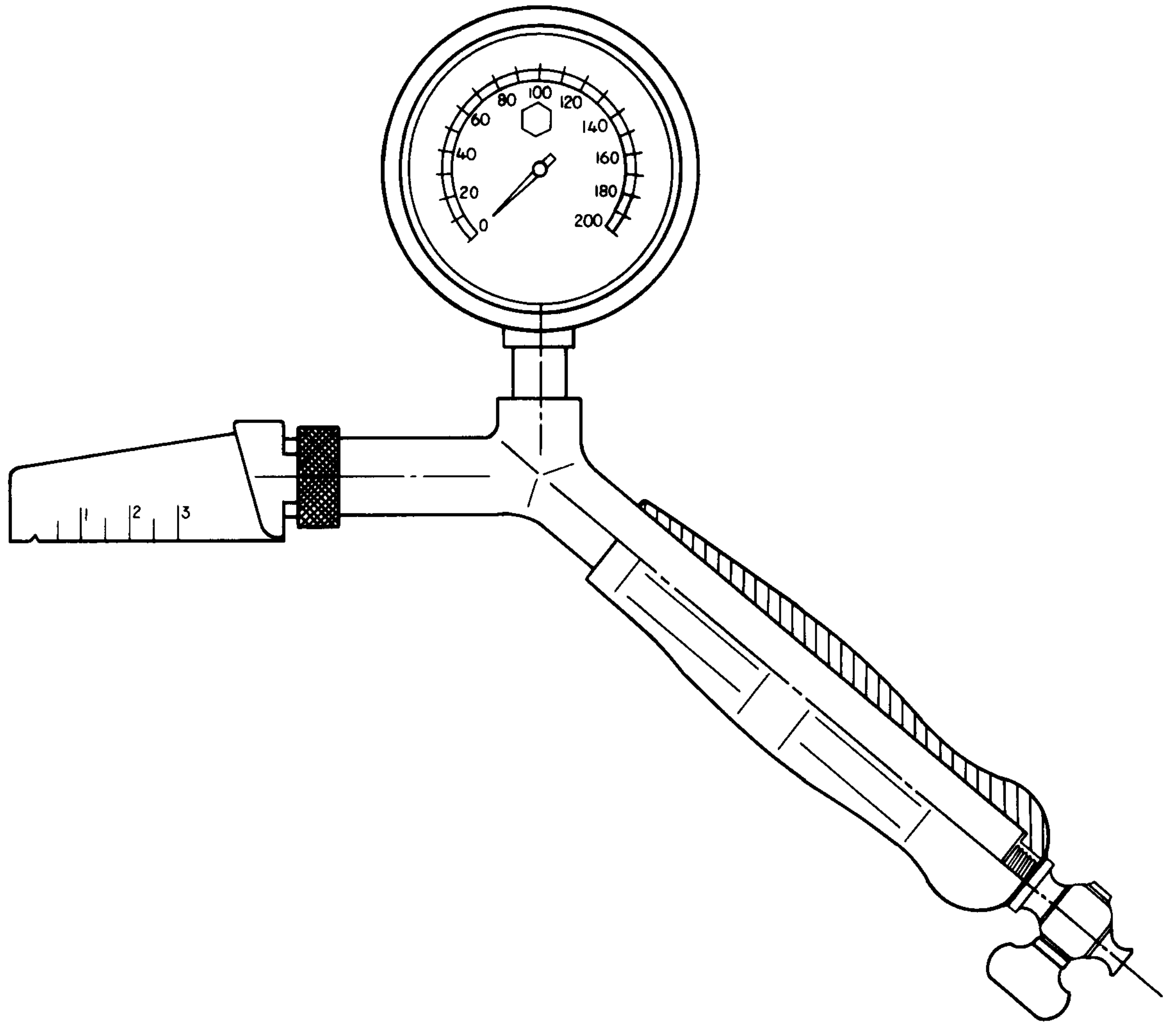

Figure A-2-3.3.1(c) Commercial pitot tube.

so as to require assurance after the repair that the pump is still operating properly.

A-3-3.3 The test should not be officially started until the pump pressure and the discharge quantity are satisfactory. Readings should be taken on the pitot gauge with sufficient frequency to obtain a good average. If the pressure varies, readings need to be taken with greater frequency than if the pressure holds steady.

A-3-3.3.1 If the pump is a two-stage (series/parallel) unit, operation of the transfer (change-over) valve should be checked thoroughly. Conducting the pumping test with the transfer valve positioned as specified in 3-3.3.1 will ensure the valve is exercised. If a comparison with the original engine speeds shows a significant difference for any of the test, one of the problems could be with the transfer valve.

A-3-3.4 Closing all discharges in less than 3 sec may cause instantaneous pressure rises that the pressure control device may not be able to respond to rapidly enough to avoid damage to the pumping system. Taking more than 10 sec to close the discharges is not a reasonable test of the pressure control device response capability. Controlling closure of the discharges may be done manually or otherwise.

A-3-3.5 Pressure gauges can be quickly checked against the test gauges for accuracy. Individual discharge lines with gauges should be capped and the discharge valve opened slightly. The test gauge, the master discharge gauge, and the discharge gauges should all read the same.

Flow meters need to be checked individually using a hose stream with a smoothbore tip and a pitot tube to measure the actual flow.

A-3-3.6 If the apparatus is equipped with a water tank, the tank-to-pump flow rate also should be checked. A procedure for testing the water tank-to-pump flow rate is as follows:

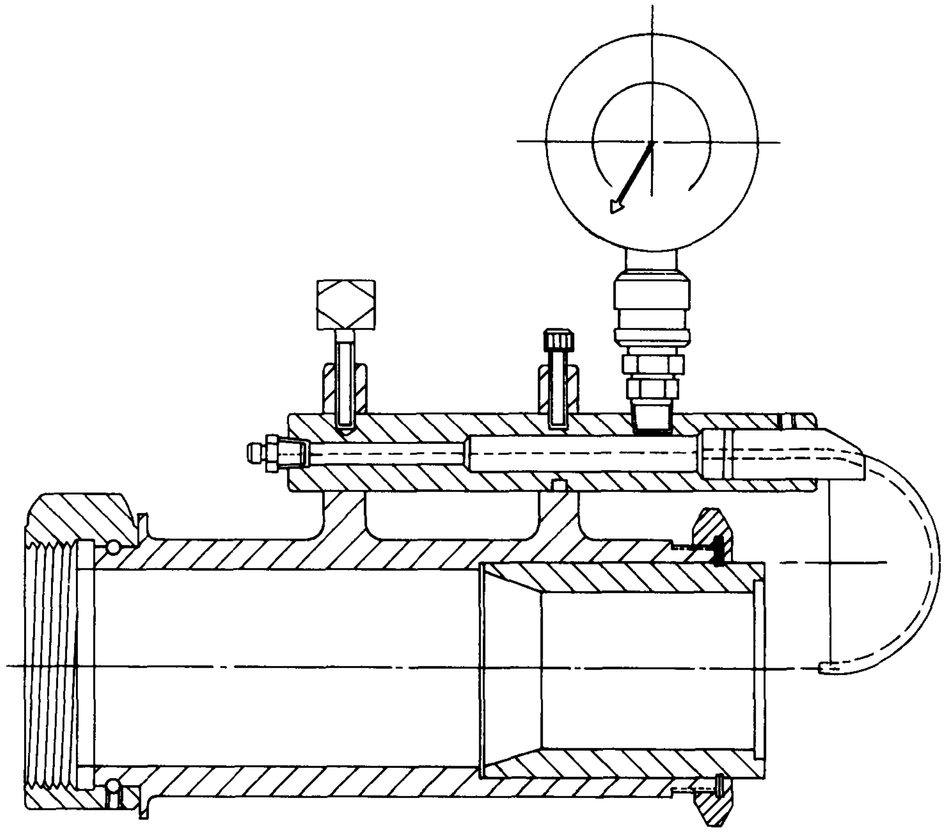

Figure A-2-3.3.1(d) Pitot tube attached to nozzle.

(a) The water tank should be filled until it overflows.

(b) All intakes to the pump should be closed.

(c) The tank fill line and/or the by-pass cooling line should be closed.

(d) Hose lines and nozzles suitable for discharging water at the manufacturer's designated flow rate should be connected to one or more of the discharge outlets.

(e) The tank-to-pump valve and the discharge valve(s) leading to the hose lines and nozzles should be fully opened.

(f) The engine throttle should be adjusted until the maximum consistent pressure reading on the discharge pressure gauge is obtained.

(g) The discharge valve(s) should be closed and the tank refilled. The by-pass line may be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.

(h) The discharge valves should be reopened fully and a pitot reading or other flow measurement taken while the water is being discharged. If necessary the engine throttle should be adjusted to maintain the discharge pressure noted in (f).

(i) The flow rate should be compared with the rate designated by the manufacturer when the apparatus was new. Rates less than the rate when the apparatus was new indicate problems in the tank-to-pump line or tank sump.

A-3-4 Some test data forms for recording the test readings and other necessary data should be provided. Figure A-3-4 is an example of a suitable form. The use of such a form will help to ensure that all needed data are obtained.

A-3-4.1 Other data that should be obtained are indicated on the test form. The layout of the hose and nozzle and data about the pump and engine should be recorded.

A-3-4.2 When a pump is operating at or near full engine power while stationary, the heat generated may raise the temperature of certain chassis and/or pumping system components above the level that can be touched without extreme discomfort or injury; however, as long as the apparatus can be operated and used satisfactorily for the required duration of the test under such conditions, and the engine coolant temperature is within normal range, it should be considered acceptable.

SERVICE TEST RESULTS

APPARATUS NUMBER: ____________________

MANUFACTURER: ____________________ YEAR BUILT: ________

MANUFACTURER'S MODEL: ____________________ SERIAL NO.: ________

ENGINE MAKE: ____________________ MODEL: ________

PUMP MAKE: ____________________ MODEL: ________

PUMP CAPACITY ____________ GPM________ PSI ________

GEAR RATIO: ENGINE TO PUMP: CAPACITY ____ 200 PSI ____ 250 PSI ____

TRANSMISSION GEAR USED: CAPACITY ____ 200 PSI ____ 250 PSI ____

SUCTION HOSE SIZE: ______ IN. LENGTH____ FT LIFT____ FT

SPEED CHECK TAKEN FROM: ____________________

RATIO TO ENGINE: ____________________

TEST SITE LOCATION: ____________________

ATMOSPHERIC PRESSURE: ____________ AIR TEMPERATURE: ____________

WATER TEMPERATURE ____________ ELEVATION OF TEST SITE: ________

NO LOAD ENGINE SPEED: ____________ RPM

VACUUM DROP IN 5 MINUTES: ____________ IN. Hg

PRESSURE CONTROL DEVICE TEST: RISE AT CAPACITY AT 150 PSIG ____________

CAPACITY AT 90 PSIG ____________ 50% CAPACITY AT 250 PSIG ____________

CAPACITY TEST

LAYOUT ____________ NOZZLE SIZE ____________

POSITION OF TRANSFER VALVE ____________

Time	Counter	RPM	Tach	Pump Pressure		Pitot
				Appar Gauge	Test Gauge	

250 PSI TEST

LAYOUT ____________ NOZZLE SIZE ____________

POSITION OF TRANSFER VALVE ____________

Time	Counter	RPM	Tach	Pump Pressure		Pitot
				Appar Gauge	Test Gauge	

200 PSI TEST

LAYOUT ____________ NOZZLE SIZE ____________

POSITION OF TRANSFER VALVE ____________

Time	Counter	RPM	TACH	Pump Pressure		Pitot
				Appar Gauge	Test Gauge	

FINAL RESULTS

	Capacity	200 psi	250 psi
Duration			
Average Noz. Pressure			
Correction			
Corrected Pressure			
Gallons Per Minute			
Average Pump Pressure*			
RPM-Engine			
RPM-Pump			

* Test Gauge Reading

REMARKS

Tested at: ____________ Witnessed by: ____________ Date: ____________

Figure A-3-4 Service test results.

Appendix B Conducting Pumping Tests

Test Parameters

At the start of the test, attention should be paid to the ease with which the pump can develop a vacuum (take suction). Before starting to prime the pump, close all discharge, drain, and booster tank valves and petcocks; make sure that the gaskets in the suction hose are in place and free of foreign matter; and tighten all intake caps and couplings.

Start the priming mechanism, noting the starting time and the time after prime is obtained. The priming device should be able to create the necessary vacuum (take suction) through 20 ft (6 m) of suction hose of the appropriate size and with up to 10 ft (3 m) of lift in 30 to 45 sec, depending upon the rated capacity of the pump. Operate the controls as necessary to develop pressure, and then open one discharge valve to permit the flow of water.

In testing a pump there are three variable factors, interrelated in that a change in one factor will always produce a change in at least one of the others. The three variables are pump speed, net pump pressure, and pump discharge rate. For example, an increase in speed of the pump will increase the discharge or the pressure or both. Adjustments of variables through changing the position of the engine throttle (modifies pump speed), changing the hose layout or discharge valve positions (modifies pump pressure), or changing the nozzle size (modifies discharge) are the only ways to reach the standard test condition desired.

The pump should be operated at reduced capacity and pressure for several minutes to allow the engine and transmission to warm up. The pump speed is gradually increased until the desired pressure at the pump is reached. If the desired pressure is not attained, a length or two of hose may have to be added, a smaller nozzle used, or a discharge valve throttled. When the desired pressure is obtained at the pump, the pitot should be read to see if the required amount of water is being delivered.

If the discharge is not as great as desired and it is believed that the pump will deliver a greater quantity of water, the discharge may be increased by further speeding up the pump, but if speeding up the pump increases the pump pressure more than 5 or 10 psi (34 or 68 kPa), a length of hose should be taken out, a discharge valve opened slightly, or a larger nozzle used.

A speed reading should be taken at frequent intervals, corresponding to the time the pressure readings were taken. Counting the revolutions for one minute generally gives readings of sufficient accuracy.

When using a stopwatch, the best and most accurate method is to leave the stopwatch running at all times, engaging the revolution counter at a chosen instant and disengaging when the hand of the stopwatch passes the same point on the dial one minute later.

After the engine has warmed up, there should be little change in the engine speed. It should be realized that any change in engine speed must, of necessity, produce a corresponding change in pump discharge pressure and hence in pitot reading and that other things being equal, any change in pitot reading indicates a change in engine speed. A change in pump speed will also cause a change in discharge pressure so that whenever pump speed, discharge pressure, and pitot readings do not show corresponding changes, it is safe to say that some reading is in error or some condition has arisen that affects the readings and needs correction. Engine speeds can be changed by working the hand throttle at the operator's position.

Automatic relief valves or pressure regulators controlling the speed of the pump should be disengaged during the test.

It is common but faulty practice to read a pressure gauge at the highest point in the swing of its needle; the center of the needle swing should always be read, as this is the average pressure. A needle valve in the line to the gauge (a "snubber") may be throttled to prevent excessive vibration, but if throttled too much the gauge pointer will no longer indicate the pressure correctly; never attempt to eliminate all of the pointer movements. Any leaks in the line to the test gauge will result in an incorrect gauge reading.

Special care should be taken in reading the pitot pressure; the pitot tube should be held in the center of the stream with the tip about half the nozzle diameter away from the end of the nozzle. If the pitot is brought closer to the nozzle, the reading will be erroneously increased.

Short lines of hose are always more convenient for a test layout than long ones. It is generally better to use a single line of 100 ft (305 m) for the pressure tests and restrict the discharge at the pump discharge valve enough to increase the friction loss so that the desired discharge pressure will be obtained. By closely watching the pitot reading, the valve can be gradually closed as the engine speed is increased until the discharge pressure and pitot pressure readings are both as desired. Care should be taken to make sure that the valve does not jar either open or closed as, in either case, both the capacity and discharge pressure will be affected.

When operating a pump it is important that the engine temperature be kept within the proper range; neither a cold engine nor an excessively hot engine will give as good service as one run at the proper temperature.

The oil pressure on the engine should be watched to see that the engine is being properly lubricated. The transmission gears should be watched for overheating. Any unusual vibration of the engine or the pump or any leak in the pump casing or connections should be noted and taken care of. Centrifugal pumps are not self-priming and could lose their prime if there was a leak in the suction line.

Other defects in the performance of the engine or the pump should be recorded. Minor defects should be corrected immediately if possible.

Trouble Shooting

Most tests are conducted without incident. Nevertheless, trouble does develop during some tests, and an effort should be made to locate the source of trouble while the apparatus remains at the test site. Some difficulties that may be experienced, and suggestions on how to trace and correct them, are discussed in the following paragraphs.

Failure to prime a centrifugal pump is a frequent source of trouble, and the usual cause is an air leak in the suction hose or pump. One way to trace this trouble is to remove all discharge hose lines, cap all discharge openings and the suction hose, and operate the priming mechanism in accordance with the manufacturer's recommendations. Study the intake gauge to determine maximum vacuum developed, which should be at least 22 in. (560 mm) of mercury at altitudes of less than 1000 ft (305 m). Stop the primer. If the vacuum drops 10 or more in. (254 mm) in less than 5 min, there is a leak in the suction hose or pump assembly; it may be in a valve, drain cock, piping, casing, or pump packing. The leakage may be located by listening for air movement. Another method is to connect the pump to a convenient hydrant, cap the pump discharge outlets, open the hydrant, and watch for water leaks. A leak can usually be corrected at the test site.

Two possible causes for failure of the pump to deliver the desired capacity and/or pressure are insufficient power and restrictions in the suction arrangement. Insufficient power is indicated by the inability of the engine to reach the required speed for the desired pumping condition. The operator may have failed to advance the throttle far enough, may be using the wrong transmission gear position, the engine may be in need of a tune-up, the grade of fuel may be improper for adequate combustion, or there may be vaporization in the fuel line.

Restriction in the suction arrangement is indicated if the pump speed is too high for the capacity and pressure levels attained and may be the result of any one or combination of the following conditions: suction hose too small, high altitude, suction lift too high, improper type of strainer, clogged suction strainer at the pump or at the end of the suction hose, aerated water, water too warm (over 90°F or 32°C), collapsed or defective suction hose, or foreign material in pump. An air leak in the suction hose connections or the pump intake manifold will also result in excessive pump speed and eventually may cause loss of prime and complete cessation of flow.

Insufficient pressure when operating a centrifugal pump may be the result of pumping too much water for the power available and, in multistage pumps, pumping in "volume" position instead of required "pressure" position. This can be checked by partially closing off all discharge valves until only a small flow is observed and then opening the throttle until the desired pressure is reached, followed by slowly opening discharge valves and increasing engine speed as necessary to maintain pressure until the desired capacity is obtained. An improperly adjusted or inoperative transfer valve may prevent building up of adequate pressure. Likewise, the automatic pressure control may be set too low or be defective.

Excessive engine speed may be the result of operating the apparatus with the wrong transmission gear in use, stuck throttle control cable, restrictions in the suction arrangement, not having the suction hose under a sufficient depth of water, or an air leak on the intake side of the pump. Of course, it may be the result of pump wear, in which case repairs must be made and another test performed subsequently.

A slip of the revolution counter or its fitting will show an apparently decreased speed, and frequent checks should be made with the apparatus tachometer to verify a change in speed. A clogged pitot tube will cause a drop in the gauge reading.

Calculating the Results

If nozzles and pitot tubes have been used to measure pump capacity, the values of capacity are determined by the following formula:

$$\text{gallons per minute} = 29.83\ c\ d^2 \sqrt{p}$$

where d = diameter of nozzle in inches

p = pressure of pitot gauge, psi
c = coefficient of discharge of the nozzle used.

The pitot pressure should be the average of several readings and corrected for gauge error.

For nozzles sized from 1/4 in. (6.3 mm) to 2 1/4 in. (57 mm), values of capacity may be approximated from Tables B-1 (a), (b), (c), and (d); however, as these values are based on certain assumed coefficients of discharge, they may be considerably at variance with the actual values. For nozzles larger than 2 1/4 in. (57 mm), approximate values of capacity may be obtained from Table B-4.

Lift

The lift is the difference in elevation between the water level and the center of the pump intake when an apparatus is drafting water. The maximum lift is the greatest difference in elevation at which the apparatus can draft the required quantity of water under the established physical characteristics of operation; these include the design of the pump, the adequacy of the engine, the condition of pump and engine, the size and condition of suction hose and strainers, the elevation of the pumping site above sea level, atmospheric pressure, and temperature of the water. The theoretical values of lift and maximum lift must be reduced by the entrance and friction losses in the suction hose equipment to obtain the actual or measurable lift.

The vacuum, or negative pressure, on the intake side of a pump is measured in inches of mercury, usually written as in. Hg or "Hg (Hg is the chemical symbol for mercury). A vacuum of one in. of mercury is equal to a negative pressure of 0.49 lb per sq in.; or 1 in. Hg = 0.49 psi. A positive pressure of 0.49 psi at the bottom of a 1-sq in. container will support a column of water 1.13 ft high; therefore, a negative pressure of 0.49 psi at the top of the container will support the same column of water. This means 1 in. Hg = 0.49 psi = 1.13 ft of water head.

Table B-1(a) Discharge Table for Smooth Nozzles

Nozzle Pressure Measured by Pitot Gauge

Nozzle Pressure in psi	1/4	5/16	3/8	7/16	Nozzle Pressure in psi	1/4	5/16	3/8	7/16
	Nozzle diam. in inches. gpm					Nozzle diam. in inches. gpm			
5	4	6	9	13	**60**	14	22	31	43
6	4	6	10	14	**62**	14	22	32	44
7	4	7	11	15	**64**	14	22	32	45
8	5	7	11	16	**66**	14	23	33	46
9	5	8	12	17	**68**	14	23	33	46
10	6	9	13	18	**70**	15	24	34	47
12	6	10	15	19	**72**	15	24	34	48
14	7	11	15	21	**74**	15	24	35	48
16	7	12	16	22	**76**	15	24	35	49
18	7	12	17	24	**78**	15	24	36	50
20	8	13	18	25	**80**	16	25	36	50
22	8	13	19	26	**82**	16	25	37	51
24	8	13	20	27	**84**	16	25	37	51
26	9	14	21	29	**86**	16	26	37	52
28	9	14	21	30	**88**	16	26	38	53
30	10	15	22	31	**90**	17	27	39	53
32	10	15	23	32	**92**	17	27	39	54
34	11	16	23	33	**94**	17	27	39	54
36	11	16	24	34	**96**	17	27	40	55
38	11	17	25	35	**98**	17	27	40	55
40	11	18	26	35	**100**	18	28	41	56
42	11	18	26	36	**105**	18	29	42	57
44	12	18	27	37	**110**	19	29	43	59
46	12	19	28	38	**115**	19	30	43	60
48	12	19	28	39	**120**	19	31	44	61
50	13	20	29	40	**125**	20	31	45	63
52	13	20	29	40	**130**	20	32	46	64
54	13	20	30	41	**135**	21	33	47	65
56	13	21	30	42	**140**	21	33	48	66
58	13	21	31	43	**145**	21	34	49	68
60	14	22	31	43	**150**	22	34	50	69

Assumed coefficient of discharge = $0.98\frac{1}{4}$ $0.98\frac{1}{4}$ $0.98\frac{1}{2}$ $0.98\frac{1}{2}$

Table B-1(b) Discharge Table for Smooth Nozzles

Nozzle Pressure Measured by Pitot Gauge

Nozzle Pressure in psi	1/2	5/8	3/4	7/8	Nozzle Pressure in psi	1/2	5/8	3/4	7/8
	Nozzle diam. in inches. gpm					Nozzle diam. in inches. gpm			
5	16	26	37	50	**60**	57	89	130	174
6	18	28	41	55	**62**	58	90	132	177
7	19	30	44	59	**64**	59	92	134	180
8	21	32	47	64	**66**	60	93	136	182
9	22	34	50	67	**68**	60	95	138	185
10	23	36	53	71	**70**	61	96	140	188
12	25	40	58	78	**72**	62	97	142	191
14	27	43	63	84	**74**	63	99	144	193
16	29	46	67	90	**76**	64	100	146	196
18	31	49	71	95	**78**	65	101	148	198
20	33	51	75	101	**80**	66	103	150	201
22	34	54	79	105	**82**	66	104	152	204
24	36	56	82	110	**84**	67	105	154	206
26	37	59	85	115	**86**	68	107	155	208
28	39	61	89	119	**88**	69	108	157	211
30	40	63	92	123	**90**	70	109	159	213
32	41	65	95	127	**92**	70	110	161	215
34	43	67	98	131	**94**	71	111	162	218
36	44	69	100	135	**96**	72	113	164	220
38	45	71	103	138	**98**	73	114	166	223
40	46	73	106	142	**100**	73	115	168	225
42	47	74	109	146	**105**	75	118	172	230
44	49	76	111	149	**110**	77	121	176	236
46	50	78	114	152	**115**	79	123	180	241
48	51	80	116	156	**120**	80	126	183	246
50	52	81	118	159	**125**	82	129	187	251
52	53	83	121	162	**130**	84	131	191	256
54	54	84	123	165	**135**	85	134	195	262
56	55	86	125	168	**140**	87	136	198	266
58	56	87	128	171	**145**	88	139	202	271
60	57	89	130	174	**150**	90	141	205	275

Assumed coefficient of discharge = $0.98\frac{1}{2}$ $0.98\frac{3}{4}$ $0.98\frac{3}{4}$ $0.98\frac{3}{4}$

Table B-1(c) Discharge Table for Smooth Nozzles

Nozzle Pressure Measured by Pitot Gauge

Nozzle Pressure in psi	Nozzle diam. in inches. 1 (gpm)	1⅛	1¼	1⅜	1½	Nozzle Pressure in psi	Nozzle diam. in inches. 1 (gpm)	1⅛	1¼	1⅜	1½
5	66	84	103	125	149	**60**	229	290	357	434	517
6	72	92	113	137	163	**62**	233	295	363	441	525
7	78	99	122	148	176	**64**	237	299	369	448	533
8	84	106	131	158	188	**66**	240	304	375	455	542
9	89	112	139	168	200	**68**	244	308	381	462	550
10	93	118	146	177	211	**70**	247	313	386	469	558
12	102	130	160	194	231	**72**	251	318	391	475	566
14	110	140	173	210	249	**74**	254	322	397	482	574
16	118	150	185	224	267	**76**	258	326	402	488	582
18	125	159	196	237	283	**78**	261	330	407	494	589
20	132	167	206	250	298	**80**	264	335	413	500	596
22	139	175	216	263	313	**82**	268	339	418	507	604
24	145	183	226	275	327	**84**	271	343	423	513	611
26	151	191	235	286	340	**86**	274	347	428	519	618
28	157	198	244	297	353	**88**	277	351	433	525	626
30	162	205	253	307	365	**90**	280	355	438	531	633
32	167	212	261	317	377	**92**	283	359	443	537	640
34	172	218	269	327	389	**94**	286	363	447	543	647
36	177	224	277	336	400	**96**	289	367	452	549	654
38	182	231	285	345	411	**98**	292	370	456	554	660
40	187	237	292	354	422	**100**	295	374	461	560	667
42	192	243	299	363	432	**105**	303	383	473	574	683
44	196	248	306	372	442	**110**	310	392	484	588	699
46	200	254	313	380	452	**115**	317	401	495	600	715
48	205	259	320	388	462	**120**	324	410	505	613	730
50	209	265	326	396	472	**125**	331	418	516	626	745
52	213	270	333	404	481	**130**	337	427	526	638	760
54	217	275	339	412	490	**135**	343	435	536	650	775
56	221	280	345	419	499	**140**	350	443	546	662	789
58	225	285	351	426	508	**145**	356	450	556	674	803
60	229	290	357	434	517	**150**	362	458	565	686	817

Assumed coefficient of discharge = 0.99 0.99 0.99 0.99¼ 0.99½

Table B-1(d) Discharge Table for Smooth Nozzles

Nozzle Pressure Measured by Pitot Gauge

Nozzle Pressure in psi	Nozzle diam. in inches. 1⅝ (gpm)	1¾	1⅞	2	2¼	Nozzle Pressure in psi	Nozzle diam. in inches. 1⅝ (gpm)	1¾	1⅞	2	2¼
5	175	203	234	266	337	**60**	607	704	810	920	1167
6	192	223	256	292	369	**62**	617	716	823	936	1187
7	207	241	277	315	399	**64**	627	727	836	951	1206
8	222	257	296	336	427	**66**	636	738	850	965	1224
9	235	273	314	357	452	**68**	646	750	862	980	1242
10	248	288	330	376	477	**70**	655	761	875	994	1260
12	271	315	362	412	522	**72**	665	771	887	1008	1278
14	293	340	391	445	564	**74**	674	782	900	1023	1296
16	313	364	418	475	603	**76**	683	792	911	1036	1313
18	332	386	444	504	640	**78**	692	803	924	1050	1330
20	350	407	468	532	674	**80**	700	813	935	1063	1347
22	367	427	490	557	707	**82**	709	823	946	1076	1364
24	384	446	512	582	739	**84**	718	833	959	1089	1380
26	400	464	533	606	769	**86**	726	843	970	1102	1396
28	415	481	554	629	799	**88**	735	853	981	1115	1412
30	429	498	572	651	826	**90**	743	862	992	1128	1429
32	443	514	591	673	854	**92**	751	872	1002	1140	1445
34	457	530	610	693	880	**94**	759	881	1012	1152	1460
36	470	546	627	713	905	**96**	767	890	1022	1164	1476
38	483	561	645	733	930	**98**	775	900	1032	1176	1491
40	496	575	661	752	954	**100**	783	909	1043	1189	1506
42	508	589	678	770	978	**105**	803	932	1070	1218	1542
44	520	603	694	788	1000	**110**	822	954	1095	1247	1579
46	531	617	710	806	1021	**115**	840	975	1120	1275	1615
48	543	630	725	824	1043	**120**	858	996	1144	1303	1649
50	554	643	740	841	1065	**125**	876	1016	1168	1329	1683
52	565	656	754	857	1087	**130**	893	1036	1191	1356	1717
54	576	668	769	873	1108	**135**	910	1056	1213	1382	1750
56	586	680	782	889	1129	**140**	927	1076	1235	1407	1780
58	596	692	796	905	1149	**145**	944	1095	1257	1432	1812
60	607	704	810	920	1168	**150**	960	1114	1279	1456	1843

Assumed coefficient of discharge = 0.995 0.995 0.996 0.997 0.997

Effect of Altitude

When drafting water, the pump produces a partial vacuum in the suction hose, and the atmospheric pressure on the surface of the water forces water into the suction hose and the pump. As the elevation above sea level of the pumping site increases, the atmospheric pressure decreases. The loss of lift at various elevations is given in Table B-2.

The data in Table B-2 assume that the engine of the apparatus is adequate at all elevations. However, the power available for driving a pump from naturally aspirated gasoline engines decreases about 4 percent (up to 3 percent for diesel engines that are naturally aspirated) for each 1000 ft (305 m) of elevation. Therefore, a gasoline engine that was just adequate at sea level would be about 35 percent deficient at 7000 ft (2135 m) altitude.

A difference in barometric pressure due to weather conditions will have the same result as a change in altitude. The difference in barometric pressure due to operation on a rainy day instead of a cool, clear day could easily mean a 1 ft (0.3m) difference in lift.

Table B-2 Loss of Lift at Various Elevations

Elevation above sea level feet	meters	Loss of lift feet of water	meters
1000	305	1.22	.37
2000	610	2.38	.73
3000	915	3.50	1.07
4000	1220	4.75	1.45
5000	1525	5.80	1.77
6000	1830	6.80	2.07
7000	2135	7.70	2.35

Pump Design and Suction Hose

At the time of purchase, a pump must be able to develop a vacuum of 22 in. of mercury (Hg) (74.5 kPa) with a capped suction hose and must hold the vacuum with a drop not in excess of 10 in. Hg (33.9 kPa) in 5 min. This is basically a test of the priming system and the tightness of the pump and fittings, not a test of the ability to maintain a vacuum while pumping water. The latter is an entirely different pump design problem.

The number of suction hoses, length and condition of hose, as well as altitude, water temperature, barometric pressure, and lift are all factors that affect pumping from draft.

The suction hose and lift are the two most common factors that affect pumping from draft. Table B-3 illustrates this effect on capacity. This table is for the purpose of illustration. Actual tests should be made on your pump to determine its maximum capacity, which in most cases will exceed the capacities shown in the table.

Table B-3 illustrates:

(a) The rated pump capacity increases below 10-ft (3-m) lift and decreases above 10-ft (3-m) lift.

(b) Larger diameter suction hose or dual suction hoses increase the capacity.

(c) When required to pump at higher lifts or elevation, capacity can be increased by using a bigger pump, larger diameter suction hose, or dual suction hoses.

Table B-3 Minimum Discharge Expected of a Pump in Good Condition Operating at Draft at Various Lifts

Rated Capacity at 150 psi		500 gpm		750 gpm		1000 gpm		1250 gpm	1500 gpm		
Suction Hose Size		4"	4½"	4½"	5"	5"	6"	6"	6"	Dual 5"	Dual 6"
Lift in Feet: 4		590	660	870	945	1160	1345	1435	1735	1990	2250
6	20' Suction Hose (Two Sections)	560	630	830	905	1110	1290	1375	1660	1990	2150
8	20' Suction Hose (Two Sections)	530	595	790	860	1055	1230	1310	1575	1810	2040
10	20' Suction Hose (Two Sections)	500	560	750	820	1000	1170	1250	1500	1720	1935
12	20' Suction Hose (Two Sections)	465	520	700	770	935	1105	1175	1410	1615	1820
14	20' Suction Hose (Two Sections)	430	480	650	720	870	1045	1100	1325	1520	1710
16	20' Suction Hose (Two Sections)	390	430	585	655	790	960	1020	1225	1405	1585
18	30' Suction Hose (Three Sections)	325	370	495	560	670	835	900	1085	1240	1420
20	30' Suction Hose (Three Sections)	270	310	425	480	590	725	790	955	1110	1270
22	30' Suction Hose (Three Sections)	195	225	340	375	485	590	660	800	950	1085
24	30' Suction Hose (Three Sections)	65	70	205	235	340	400	495	590	730	835

Example: Effect of larger suction hose

1000 gpm capacity

10-ft lift with 5-in. suction hose	1000 gpm
10-ft lift with 6-in. suction hose	1170 gpm
minimum increase most pumps	170 gpm

From Table 2-3.1(b) for suction hose and strainer loss

1000 gpm through 5-in. hose and strainer 8.4 ft

1000 gpm through 6-in. hose and strainer 3.4 ft

Difference 5.0 ft

This 5 ft of difference has the potential to compensate for either 5 ft of additional lift or the ability to pump rated capacity to 4250 ft of elevation (*see Table B-2*).

Table B-4 Nozzle Factors

Diameter of the nozzle in inches	Factors Fresh Water	Salt (sea) Water
2	119	117
2¼	150	148
2½	186	183
2¾	225	222
3	267	264
3¼	314	310
3½	364	359
3¾	418	413
4	476	470
4¼	537	530
4½	602	594
4¾	671	662
5	743	734
6	1070	1057

Capacity in gallons per minute is determined by the following formula:

$$gpm = (F)\sqrt{p}$$

F = factor from the table

p = pressure at pitot gauge, psi

Appendix C

History

A pamphlet entitled *Fire Department Pumper Tests and Fire Stream Tables*, published in 1910, described the methods of testing steam fire engines, which had been in use for years, and stated that these tests had been found practicable, exact, and of great value. Until then, the character of tests made in many cities, and especially those for acceptance, were usually more spectacular than exact.

At the convention of the International Association of Fire Engineers in Milwaukee in 1911, the Committee on Exhibits conducted some performance tests on automobile pumping engines. The following year at Denver, the Committee on Exhibits, with the assistance of engineers of the National Board of Fire Underwriters, conducted tests on 7 pumping engines discharging under net pumping pressures of 120 psi, 200 psi, and 250 psi; duration of various runs was from 3 to 11 min. By the next convention of the IAFE in New York City in 1913, the Committee had developed the test procedure that consisted of 6 hr running at capacity at 120 psi, 3 hr running at $\frac{1}{2}$ capacity at 200 psi, and 3 hr running at $\frac{1}{3}$ capacity at 250 psi. This test procedure was used for many years.

The 1939 and 1941 editions of the *Suggested Specifications for Motor Fire Apparatus*, issued by the National Board of Fire Underwriters, outlined the above-mentioned tests, which were later termed "Class B" requirements; the "Class A" requirements, delivery of capacity at 150 psi, 70 percent of capacity at 200 psi, and delivery of 50 percent of capacity at 250 psi, were noted as an optional specification. The 1947 edition defined the two classes, and the 1956 edition eliminated the Class B designation.

As a result of this gradual change, most pumpers built prior to 1939 were Class B, those built from 1939 through 1956 were Class A or B, and those built from 1957 on are Class A.

The fifth edition of *Fire Department Pumper Tests and Fire Stream Tables* (1950) described the test for what had been established as Class A pumpers, which specified the delivery of rated capacity at 150 psi, 70 percent of capacity at 200 psi, and 50 percent of capacity at 250 psi. This is the test now in use; Class B pumpers are no longer recognized for original purchase.

In January 1981, the Insurance Services Office, successor to the former National Board of Fire Underwriters, transferred all publishing rights of this pamphlet to the National Fire Protection Association. In the NFPA publication, SPP-67, several changes were made, including:

1. A modification of the description of the type of tests performed to correlate with requirements contained in NFPA 1901, *Standard on Automotive Fire Apparatus*.

2. Reduction in the test dealing with testing of positive displacement pumps, especially rotary gear pumps.

3. Insertion of additional cautionary statements and increased emphasis on safety precautions that should be followed during tests.

4. A new table showing the relative carrying capacity of hose from 63 to 150 mm in diameter.

In 1982, the NFPA Technical Committee on Fire Department Equipment began the development of this standard, which incorporates much of the material formerly included in the pamphlet but presents it in proper form for incorporation in purchase specifications and other formal documents. This standard was adopted by the NFPA in 1987.

In 1991, the NFPA adopted revisions to NFPA 1901, *Automotive Fire Apparatus*, which split the document into four documents. The four documents cover the construction and equipping of Pumpers, Initial Attack Fire Apparatus, Mobile Water Supply Fire Apparatus, and Aerial Ladder and Elevating Platform Fire Apparatus. These documents contain requirements for fire pumps and attack pumps. The requirements for the acceptance testing of these pumps was included in the four documents, and NFPA 1911 was rewritten as necessary to cover the periodic service testing. The requirements were expanded to include attack pumps, and the title was changed to the current title.

This edition brings all the material previously referenced to NFPA 1901 into the document so the document is freestanding. The previously allowed alternative of testing from a hydrant or positive pressure source of water was deleted. Requirements were added for an engine speed check, a vacuum test, a pressure control test, checking the proper operation of the transfer valve, and checking the accuracy of the gauges and flow meters.

Appendix D Referenced Publications

D-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

D-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 1961, *Standard on Fire Hose*, 1987 edition

NFPA 1962, *Standard for the Care, Use, and Maintenance of Fire Hose Including Couplings and Nozzles*, 1988 edition.

D-1.2 ANSI Publication. American National Standards Institute, 1403 Broadway, New York, NY 10018.

ANSI B40.1-1985, *Gauges—Pressure Indicating Dial Type—Elastic Element*

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The NFPA Codes and Standards Development Process

Since 1896, one of the primary purposes of the NFPA has been to develop and update the standards covering all areas of fire safety.

Calls for Proposals
The code adoption process takes place twice each year and begins with a call for proposals from the public to amend existing codes and standards or to develop the content of new fire safety documents.

Report on Proposals
Upon receipt of public proposals, the technical committee members meet to review, consider, and act on the proposals. The public proposals – together with the committee action on each proposal and committee-generated proposals – are published in the NFPA's Report on Proposals (ROP). The ROP is then subject to public review and comment.

Report on Comments
These public comments are considered and acted upon by the appropriate technical committees. All public comments – together with the committee action on each comment – are published as the Committee's supplementary report in the NFPA's Report on Comments (ROC).

The committee's report and supplementary report are then presented for adoption and open debate at either of NFPA's semi-annual meetings held throughout the United States and Canada.

Association Action
The Association meeting may, subject to review and issuance by the NFPA Standards Council, (a) adopt a report as published, (b) adopt a report as amended, contingent upon subsequent approval by the committee, (c) return a report to committee for further study, and (d) return a portion of a report to committee.

Standards Council Action
The Standards Council will make a judgement on whether or not to issue an NFPA document based upon the entire record before the Council, including the vote taken at the Association meeting on the technical committee's report.

Voting Procedures
Voting at an NFPA Annual or Fall Meeting is restricted to members of record for 180 days prior to the opening of the first general session of the meeting, except that individuals who join the Association at an Annual or Fall Meeting are entitled to vote at the next Fall or Annual Meeting.

"Members" are defined by Article 3.2 of the Bylaws as individuals, firms, corporations, trade or professional associations, institutes, fire departments, fire brigades, and other public or private agencies desiring to advance the purposes of the Association. Each member shall have one vote in the affairs of the Association. Under Article 4.5 of the Bylaws, the vote of such a member shall be cast by that member individually or by an employee designated in writing by the member of record who has registered for the meeting. Such a designated person shall not be eligible to represent more than one voting privilege on each issue, nor cast more than one vote on each issue.

Any member who wishes to designate an employee to cast that member's vote at an Association meeting in place of that member must provide that employee with written authorization to represent the member at the meeting. The authorization must be on company letterhead signed by the member of record, with the membership number indicated, and the authorization must be recorded with the President of NFPA or his designee before the start of the opening general session of the Meeting. That employee, irrespective of his or her own personal membership status, shall be privileged to cast only one vote on each issue before the Association.