NFPA 1911

Standard for Service Tests of Fire Pump Systems on Fire Apparatus

2002 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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This edition of NFPA 1911, *Standard for Service Tests of Fire Pump Systems on Fire Apparatus*, was prepared by the Technical Committee on Fire Department Apparatus and acted on by NFPA at its May Association Technical Meeting held May 19–23, 2002, in Minneapolis, MN. It was issued by the Standards Council on July 19, 2002, with an effective date of August 8, 2002, and supersedes all previous editions.

This edition of NFPA 1911 was approved as an American National Standard on July 19, 2002.

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.

With the 1991 edition, the requirements for acceptance tests of new apparatus were transferred to the standards for new fire apparatus. Material previously referenced from other documents was added to make this document self-contained. The requirements were changed to include pumps that were 250 gpm (1000 L/min) and larger and were rated at 150 psi (1000 kPa).

The 1997 edition expanded the tables to include data for pumps to 3000 gpm (12,000 L/min), added accuracy requirements for flow and speed measuring equipment, and required a tank-to-pump flow-rate check. The name of the standard was changed to reflect that components of the pumping system, such as the tank-to-pump piping, were being checked.

This edition reorganizes the text to reflect the new NFPA *Manual of Style*. While metric units have been left as the second value shown, they have been updated to reflect values that are appropriate for testing fire pumps built to metric standards. An equivalency statement has been added and tables added that give metric values for friction and entrance loss in suction hose. New requirements address the testing of the priming device, the intake relief valve system, and, if the pump is rated at 750 gpm or more, the pumping engine overload capability. A general editorial cleanup has been done to clarify ambiguous and nondefinitive wording.

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Committee Scope: This Committee shall have primary responsibility for documents on the design and performance of fire apparatus for use by the fire service.

This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex D lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1 Scope. This standard shall cover the service testing of fire pump systems on automotive fire apparatus.

1.2 Purpose. This standard shall establish the site, environmental, and equipment requirements for proper pump system performance testing, as well as the frequency and procedures to be followed in performing tests.

1.3* Application. This standard shall apply to the conduct of in-service tests of fire pump systems on fire apparatus to ensure that the pump continues to be capable of the performance for which it was designed.

1.4 Equivalency. Nothing in this standard shall prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.5 Units and Formulas. In this standard, values for measurement are followed by an equivalent in metric units. The second set of values shall be used if the pumping unit was originally rated using metric values. Table 1.5 provides the user with conversion factors that can be used if more precision is required.

Table 1.5 Conversion Factors

U.S. Customary		Metric
One gallon per minute (gpm)	=	3.785 liters per minute (L/min)
One gallon per minute (gpm)	=	0.833 imperial gallons per minute
One pound per square inch (psi)	=	0.0690 bar
One pound per square inch (psi)	=	2.31 ft of water
One inch of mercury (in. Hg)	=	0.0340 bar
One inch (in.)	=	25.40 millimeters (mm)
One foot (ft)	=	0.305 meters (m)
One cubic foot (ft^3)	=	0.0283 cubic meters (m^3)

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. (Reserved)

2.3 Other Publications.

2.3.1 ASME Publication. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 1998.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1* Automatic Electrical Load Management System. A device that continuously monitors the electrical system voltage and sheds predetermined loads in a selected order to prevent overdischarging of the apparatus' batteries.

3.3.2* Compound Gauge. A gauge that indicates pressure both above and below atmospheric pressure. [**1901**:1.7]

3.3.3 Defect. A discontinuity in a part or a failure to function that interferes with the service or reliability for which the part was intended. [**1901**:1.7]

3.3.4 Fire Apparatus. A vehicle designed to be used under emergency conditions to transport personnel and equipment, and to support the suppression of fires and mitigation of other hazardous situations.

3.3.5 Fire Pump. A water pump with a rated capacity of 250 gpm (1000 L/min) or greater at 150 psi (10 bar) net pump pressure that is mounted on a fire apparatus and used for fire fighting.

3.3.6 Gallons. The designation for U.S. gallons.

3.3.7 Gauge. A round, analog, pressure-indicating device that uses mechanical means to measure pressure.

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

3.3.9 Manufacturer. The person(s), company, firm, corporation, partnership, or organization that is responsible for turning raw materials or components into a finished product. [**1901**:1.7]

3.3.10 Pressure.

3.3.10.1 Discharge Pressure. The water pressure on the discharge manifold of the fire pump at the point of gauge attachment.

3.3.10.2 Gauge Pressure. Pressure measured by an instrument where the pressure indicated is relative to atmospheric pressure.

3.3.10.3 Intake Pressure. The pressure on the intake passageway of the pump at the point of gauge attachment.

3.3.10.4 Negative Pressure. Pressure that is lower than atmospheric pressure.

3.3.10.5* Net Pump Pressure. The sum of the discharge pressure and the suction lift converted to psi or bar 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.

3.3.11* Rated Capacity. The flow rate to which the fire pump manufacturer certifies compliance of the pump when it is new.

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

3.3.13* Vacuum. The reduction in atmospheric pressure inside a pump or suction hose.

Chapter 4 Equipment and Site Requirements

4.1 Test Site.

4.1.1* Test Site from Draft. 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.

4.1.2* Test Site from Hydrant. The site shall provide an area for stationing the apparatus, a hydrant(s) capable of flowing the rated capacity of the pump, and an adjacent area where the water can be discharged.

4.2* Environmental Conditions. Tests shall be performed when the environmental conditions are within the limits shown in Table 4.2.

Table 4.2 Environmental Conditions for Testing Pumps

Condition	Limits
Air temperature	0°F to 110°F (–18°C to 43°C)
Water temperature	35°F to 90°F (2°C to 32°C)
Barometric pressure	29 in. Hg (0.982 bar), minimum (corrected to sea level)

4.3 Equipment.

4.3.1 Suction or Intake Hose.

4.3.1.1* Suction Hose and Strainer from Draft. When a pump is tested from draft at elevations up to 2000 ft (610 m), the suction hose arrangement shall be as defined in 4.3.1.1.1 or 4.3.1.1.2 as appropriate.

4.3.1.1.1 If the pump was originally rated in gallons per minute at pressures measured in pounds per square inch, 20 ft (6 m) of suction hose of the appropriate size for the rated capacity of the pump as shown in Table 4.3.1.1.1(a) shall be used. A suction strainer and hose that will allow flow with total friction and entrance loss not greater than that specified in Table 4.3.1.1.1(b) through Table 4.3.1.1.1(d) shall be used.

Table 4.3.1.1.1(a) Suction Hose Size, Number of Suction Lines, and Lift for Fire Pump

Rated Capacity (gpm)	Maximum Suction Hose Size (in.)	Maximum Number of Suction Lines	Maximum Lift (ft)
250	3	1	10
300	3	1	10
350	4	1	10
450	4	1	10
500	4	1	10
600	4	1	10
700	4	1	10
750	4½	1	10
1000	5	1	10
1250	6	1	10
1500	6	2	10
1750	6	2	8
2000	6	2	6
2250	8	3	6
2500	8	3	6
2750	8	4	6
3000	8	4	6

4.3.1.1.2 If the pump was originally rated in liters per minute at pressures measured in bars, 6 m of suction hose of the appropriate size for the rated capacity of the pump as shown in Table 4.3.1.1.2(a) shall be used. A suction strainer and hose that will allow flow with total friction and entrance loss not greater than that specified in Table 4.3.1.1.2(b) through Table 4.3.1.1.2(d) shall be used.

4.3.1.2 Intake Hose from Hydrant. When testing a pump from a hydrant, the intake hose shall be of a size and length that will allow the necessary amount of water to reach the pump with a minimum intake gauge pressure of 20 psi (1.4 bar) while flowing rated capacity. Only the strainer at the pump intake connection shall be required.

Table 4.3.1.1.1(b) Friction and Entrance Loss in 20 ft of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	3 in.		3½ in.		4 in.		4½ in.		5 in.	
Flow Rate (gpm)	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of 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	0.6(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

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

Table 4.3.1.1.1(c) Friction and Entrance Loss in 20 ft of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	4 in.		4½ in.		5 in.		6 in.		Two 4½ in.	
Flow Rate gpm	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg
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
1050							3.7 (0.7)	3.3	3.9 (0.8)	3.4
750							1.9 (0.4)	1.7	2.0 (0.4)	1.8
1750							10.4 (1.8)	9.3	11.0 (2.2)	9.7
1225							5.0 (0.9)	4.6	5.3 (1.1)	4.7
875							2.6 (0.5)	2.3	2.8 (0.6)	2.5
2000									14.5 (2.8)	12.5
1400									7.0 (1.4)	6.2
1000									3.6 (0.8)	3.2

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

Table 4.3.1.1.1(d) Friction and Entrance Loss in 20 ft of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	Two 5 in.		Two 6 in.		Three 6 in.		8 in.		Two 8 in.	
Flow Rate (gpm)	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg	ft of water*	in. Hg
1500	4.7 (0.9)	4.2	1.9 (0.4)	1.7						
1050	2.3 (0.5)	2.0	0.9 (0.3)	0.8						
750	1.2 (0.2)	1.1	0.5 (0.1)	0.5						
1750	6.5 (1.2)	5.7	2.6 (0.5)	2.3						
1225	3.1 (0.7)	2.7	1.2 (0.3)	1.1						
875	1.6 (0.3)	1.4	0.7 (0.2)	0.6						
2000	8.4 (1.6)	7.4	3.4 (0.6)	3.0			4.3 (1.1)	3.8		
1400	4.1 (0.8)	3.7	1.7 (0.3)	1.5			2.0 (0.6)	1.8		
1000	2.1 (0.4)	1.9	0.9 (0.2)	0.8			1.0 (0.3)	0.9		
2250	10.8 (2.2)	9.5	4.3 (0.8)	3.8	2.0 (0.5)	1.8	5.6 (1.4)	5.0	1.2 (0.4)	1.1
1575	5.3 (1.1)	4.7	2.2 (0.4)	1.9	1.0 (0.2)	0.9	2.5 (0.9)	2.2	0.6 (0.2)	0.5
1125	2.8 (0.5)	2.5	1.1 (0.2)	1.0	0.5 (0.1)	0.5	1.2 (0.4)	1.1	0.3 (0.1)	0.3
2500	13.0 (2.4)	11.5	5.2 (0.9)	4.7	2.3 (0.6)	2.0	7.0 (1.7)	6.2	1.5 (0.4)	1.3
1750	6.5 (1.2)	5.7	2.6 (0.5)	2.3	1.2 (0.2)	1.1	3.2 (1.0)	2.8	0.8 (0.2)	0.7
1250	3.3 (0.7)	2.9	1.3 (0.3)	1.1	0.6 (0.1)	0.5	1.5 (0.4)	1.3	0.4 (0.1)	0.4
3000			7.6 (1.4)	6.9	3.4 (0.6)	3.0	10.1 (3.0)	9.0	2.3 (0.6)	2.1
2100			3.7 (0.7)	3.4	1.7 (0.3)	1.5	4.7 (1.3)	4.2	1.0 (0.3)	0.9
1500			1.9 (0.4)	1.7	0.9 (0.2)	0.8	2.3 (0.7)	2.1	0.6 (0.2)	0.5

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

Table 4.3.1.1.2(a) Suction Hose Size, Number of Suction Lines, and Lift for Fire Pump

Rated Capacity (L/min)	Maximum Suction Hose Size (mm)	Maximum Number of Suction Lines	Maximum Lift (m)
1,000	76	1	3
1,100	76	1	3
1,300	100	1	3
1,700	100	1	3
2,000	100	1	3
2,200	100	1	3
2,600	100	1	3
3,000	110	1	3
4,000	125	1	3
5,000	150	1	3
6,000	150	2	3
7,000	150	2	2.4
8,000	150	2	1.8
9,000	200	3	1.8
10,000	200	3	1.8
11,000	200	4	1.8
12,000	200	4	1.8

4.3.2 Discharge Hose.

4.3.2.1* The fire hose arrangement shall allow discharge of the rated capacity of the pump to the nozzles or other flow-measuring equipment without exceeding a flow velocity of 35 ft/sec (10.7 m/sec).

4.3.2.2 To ascertain if the hose and coupling are starting to separate, the hose shall be marked immediately behind each coupling. If the hose stretches from the coupling more than ⅜ in. (10 mm), the test shall be stopped and that section of hose shall be replaced.

4.3.3 Flow-Measuring Equipment.

4.3.3.1 Any flow-measuring equipment that is used shall be capable of measuring the volume to within ±5 percent accuracy.

4.3.3.2* Where nozzles are used for flow measurements, they shall be used in accordance with 4.3.3.2.1 through 4.3.3.2.3.

4.3.3.2.1 The nozzle(s) shall be smoothbore.

4.3.3.2.2* Pitot tubes shall be used to measure the flow.

4.3.3.2.3 A monitor or other device shall be used to prevent movement of the nozzle.

4.3.4 Pressure-Measuring Equipment.

4.3.4.1* All test gauges shall meet the requirements for Grade A gauges as defined in ASME B40.100, *Pressure Gauges and Gauge Attachments*.

4.3.4.2 The pump intake test gauge shall be at least a size 3½ per ASME B40.100, paragraph 3.1, and shall have a range of 30 in. Hg (1 bar) vacuum to zero for a vacuum gauge, or 30 in. Hg (1 bar) vacuum to 150 psi (10 bar) for a compound gauge. A mercury manometer shall be permitted to be used in lieu of a pump intake gauge if the tests are being conducted from draft.

4.3.4.3 The discharge pressure test gauge shall be at least a size 3½ per ASME B40.100, paragraph 3.1, and shall have a range of 0 psi to 400 psi (0 bar to 28 bar).

4.3.4.4 Pitot gauges shall be at least a size 2½ per ASME B40.100, paragraph 3.1, and shall have a range of at least 0 psi to 160 psi (0 bar to 11 bar).

Table 4.3.1.1.2(b) Friction and Entrance Loss in 6 m of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	76 mm		90 mm		100 mm		113 mm		125 mm	
Flow Rate L/min	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar
1000	1.6(0.4)	0.16								
700	0.8(0.2)	0.08								
500	0.4(0.1)	0.04								
1100	2.3(0.5)	0.22	1.1 (0.2)	0.10						
770	1.2(0.2)	0.12	0.5 (0.1)	0.05						
550	0.6(0.1)	0.06	0.3 (0.1)	0.03						
1300			1.5 (0.3)	0.14	0.8 (0.2)	0.07				
910			0.7 (0.2)	0.07	0.4 (0.1)	0.04				
650			0.4 (0.1)	0.04	0.2 (0.0)	0.02				
1700					1.3(0.3)	0.12	0.8 (0.1)	0.09		
1190					0.6 (0.2)	0.06	0.4 (0.1)	0.04		
850					0.3 (0.1)	0.03	0.2 (0.0)	0.02		
2000					1.5 (0.4)	0.15	1.1(0.2)	0.11		
1400					0.8 (0.2)	0.07	0.5 (0.1)	0.05		
1000					0.4 (0.1)	0.04	0.3 (0.1)	0.03		
2200					2.2 (0.5)	0.22	1.6 (0.3)	0.16	0.9 (0.2)	0.09
1540					1.1 (0.3)	0.10	0.8 (0.2)	0.07	0.5 (0.1)	0.05
1100					0.5 (0.1)	0.05	0.4 (0.1)	0.03	0.2 (0.0)	0.02
2600					3.0 (0.8)	0.29	2.2 (0.4)	0.22	1.3 (0.2)	0.13
1820					1.5 (0.3)	0.15	1.1 (0.2)	0.10	0.6 (0.1)	0.06
1300					0.8 (0.2)	0.07	0.5 (0.1)	0.05	0.3 (0.1)	0.03

*Figures in parentheses indicate increments to be added or subtracted for each 3 m of hose less than or greater than 6 m.

Table 4.3.1.1.2(c) Friction and Entrance Loss in 6 m of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	100 mm		113 mm		125 mm		150 mm		Two 113 mm	
Flow Rate L/min	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar
3000	3.5 (0.9)	0.33	2.4 (0.5)	0.24	1.4 (0.3)	0.14	0.6 (0.1)	0.06		
2100	1.7 (0.5)	0.17	1.2 (0.2)	0.12	0.7 (0.2)	0.07	0.3 (0.1)	0.03		
1500	0.9 (0.2)	0.08	0.6 (0.1)	0.06	0.4 (0.1)	0.04	0.2 (0.0)	0.02		
4000			4.4 (0.9)	0.42	2.6 (0.5)	0.25	1.0 (0.2)	0.10		
2800			2.1 (0.4)	0.21	1.3 (0.2)	0.13	0.5 (0.1)	0.05		
2000			1.1 (0.2)	0.11	0.6 (0.1)	0.06	0.3 (0.1)	0.03		
5000					4.0 (0.7)	0.39	1.6 (0.3)	0.16	1.7 (0.4)	0.17
3500					2.0 (0.4)	0.19	0.8 (0.2)	0.08	0.9 (0.2)	0.08
2500					1.0 (0.2)	0.10	0.4 (0.1)	0.04	0.4 (0.1)	0.04
6000							2.3 (0.4)	0.23	2.4 (0.5)	0.24
4200							1.1 (0.2)	0.11	1.2 (0.2)	0.12
3000							0.6 (0.1)	0.06	0.6 (0.1)	0.06
7000							3.2 (0.5)	0.31	3.4 (0.7)	0.33
4700							1.5 (0.3)	0.16	1.6 (0.3)	0.16
3500							0.8 (0.2)	0.08	0.9 (0.2)	0.08
8000									4.4 (0.9)	0.42
5600									2.1 (0.4)	0.21
4000									1.1 (0.2)	0.11

*Figures in parentheses indicate increments to be added or subtracted for each 3 m of hose less than or greater than 6 m.

Table 4.3.1.1.2(d) Friction and Entrance Loss in 6 m of Suction Hose Including Strainer

	Suction Hose Size (inside diameter)									
	Two 125 mm		Two 150 mm		Three 150 mm		200 mm		Two 200 mm	
Flow Rate (L/min)	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar	m of water*	bar
6000	1.4 (0.3)	0.14	0.6 (0.1)	0.06						
4200	0.7 (0.2)	0.07	0.3 (0.1)	0.03						
3000	0.4 (0.1)	0.04	0.2 (0.0)	0.02						
7000	2.0 (0.4)	0.19	0.8 (0.2)	0.08						
4700	0.9 (0.2)	0.09	0.4 (0.1)	0.04						
3500	0.5 (0.1)	0.05	0.2 (0.1)	0.02						
8000	2.6 (0.5)	0.25	1.0 (0.2)	0.10			1.3 (0.3)	0.13		
5600	1.3 (0.2)	0.13	0.5 (0.1)	0.05			0.6 (0.2)	0.06		
4000	0.6 (0.1)	0.06	0.3 (0.1)	0.03			0.3 (0.1)	0.03		
9000	3.3 (0.7)	0.32	1.3 (0.2)	0.13	0.6 (0.2)	0.06	1.7 (0.4)	0.17	0.4 (0.1)	0.04
6300	1.6 (0.3)	0.16	0.7 (0.1)	0.06	0.3 (0.1)	0.03	0.8 (0.3)	0.07	0.2 (0.1)	0.02
4500	0.9 (0.2)	0.08	0.3 (0.1)	0.03	0.2 (0.0)	0.02	0.4 (0.1)	0.04	0.1 (0.0)	0.01
10000	4.0 (0.7)	0.39	1.6 (0.3)	0.16	0.7 (0.2)	0.07	2.1 (0.5)	0.21	0.5 (0.1)	0.04
7000	2.0 (0.4)	0.19	0.8 (0.2)	0.08	0.4 (0.1)	0.04	1.0 (0.3)	0.09	0.2 (0.1)	0.02
5000	1.0 (0.2)	0.10	0.4 (0.1)	0.04	0.2 (0.0)	0.02	0.5 (0.1)	0.04	0.1 (0.0)	0.01
12000			2.3 (0.4)	0.23	1.0 (0.2)	0.10	3.1 (0.9)	0.31	0.7 (0.2)	0.07
8400			1.1 (0.2)	0.12	0.5 (0.1)	0.05	1.4 (0.4)	0.14	0.3 (0.1)	0.03
6000			0.6 (0.1)	0.06	0.3 (0.1)	0.03	0.7 (0.2)	0.07	0.2 (0.1)	0.02

*Figures in parentheses indicate increments to be added or subtracted for each 3 m of hose less than or greater than 6 m.

4.3.4.5 All test gauges shall have been calibrated within 60 days preceding the tests. Calibrating equipment shall consist of a dead-weight gauge tester or a master gauge meeting the requirements for Grade 3A or 4A gauges, as defined in ASME B40.100, that has been calibrated within the preceding year.

4.3.4.6 All test 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.

4.3.5* Speed-Measuring Equipment. The engine speed-measuring equibpment shall consist of a nonadjustable tachometer supplied from the engine or transmission electronics, a revolution counter on a checking shaft outlet and a stop watch, or other engine speed-measuring means that is accurate to within ±50 rpm of actual speed.

Chapter 5 Service Tests

5.1* 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.

5.2* Conditions for Test.

5.2.1 Service tests shall be conducted at a site meeting the conditions outlined in Section 4.1 and at a time when the environmental conditions are as defined in Section 4.2.

5.2.2 If it is impractical to provide all the conditions specified in Section 4.1 and Section 4.2, the authority having jurisdiction shall be permitted to authorize tests under other conditions.

5.2.3* Engine-Driven Accessories.

5.2.3.1 Engine-driven accessories shall not be functionally disconnected or otherwise rendered inoperative during the tests.

5.2.3.2 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.

5.2.3.3 If any electrical loads are connected through an automatic electrical load management system, that system shall be permitted to automatically disconnect those loads during the course of the test.

5.2.4 Carbon Monoxide Monitoring.

5.2.4.1 Where tests are performed inside a structure or anywhere having limited air circulation, carbon monoxide–monitoring equipment shall be used.

5.2.4.2 Carbon monoxide–monitoring equipment shall be checked and calibrated in accordance with the manufacturer's recommendations and shall include a warning device.

5.3 Procedure.

5.3.1* General. The ambient air temperature, water temperature, lift, elevation of test site, and atmospheric pressure (corrected to sea level) shall be determined and recorded prior to and immediately after the pump test.

5.3.2 Engine Speed Check. A check of the governed engine speed shall be made. If the engine speed is not within ±50 rpm of the 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.

5.3.3 Priming Device Tests. If the pump is tested from draft, a priming device test shall be conducted. The test shall be permitted to be performed in connection with priming the pump for the pumping test.

5.3.3.1 With the apparatus set up for the pumping test, the primer shall be operated in accordance with the manufacturer's instructions until the pump has been primed and is discharging water.

5.3.3.2 The interval from the time the primer is started until the time the pump is discharging water shall be noted.

5.3.3.3 The time required to prime the pump shall not exceed 30 seconds if the rated capacity is 1250 gpm (4732 L/min) or less.

5.3.3.4 The time required to prime the pump shall not exceed 45 seconds if the rated capacity is 1500 gpm (5678 L/min) or more.

5.3.3.5 An additional 15 seconds shall be permitted in order to meet the requirements of 5.3.3.3 or 5.3.3.4 when the pump system includes an auxiliary 4 in. (100 mm) or larger intake pipe having a volume of 1 ft^3 (0.0283 m^3) or more.

5.3.4* Vacuum Test. The interior of the pump shall be subjected to a vacuum test as follows:

(1) All intake valves shall be open, all intakes capped or plugged, and all discharge caps removed.
(2) The primer shall be operated in accordance with the manufacturer's instructions.
(3) The maximum vacuum attained shall be at least 22 in. Hg (0.75 bar). At altitudes above 2000 ft (610 m), the vacuum attained shall be permitted to be less than 22 in. Hg (0.75 bar) by 1 in. Hg (0.034 bar) for each 1000 ft (305 m) of altitude above 2000 ft (610 m).
(4) The vacuum shall not drop more than 10 in. Hg (0.34 bar) in 5 minutes.
(5) The primer shall not be used after the 5-minute test period has begun.
(6) The engine shall not be operated at any speed greater than the governed speed during this test.

5.3.5 Pumping Test.

5.3.5.1 The pump shall be subjected to a pumping test consisting of the following:

(1) At least 20 minutes of pumping at 100 percent of rated capacity at 150 psi (10 bar) net pump pressure
(2) At least 10 minutes of pumping 70 percent of rated capacity at 200 psi (14 bar) net pump pressure
(3) At least 10 minutes of pumping 50 percent of rated capacity at 250 psi (17 bar) net pump pressure

5.3.5.2 Overload Test.

5.3.5.2.1 If the pump has a rated capacity of 750 gpm (3000 L/min) or greater, the apparatus shall be subjected to an overload test consisting of pumping rated capacity at 165 psi (11 bar) net pump pressure for at least 5 minutes.

5.3.5.2.2 The overload test shall be performed immediately following the test of pumping rated capacity at 150 psi (10 bar) net pump pressure.

5.3.5.3 The pumping tests shall not be started until the pump pressure and the discharge quantity are satisfactory.

5.3.5.4* 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 shall be permitted to 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.

5.3.5.5 The engine shall not be throttled down except when the hose, a nozzle, or the position of a transfer valve is being changed.

5.3.5.6 A complete set of readings shall be taken and recorded a minimum of five times during the 20-minute test for 100 percent rated capacity, a minimum of twice during the overload test, and a minimum of three times during each of the 10-minute tests for 70 percent capacity and 50 percent capacity.

5.3.5.7 If the fire pump flow or pressure readings vary by more than 5 percent during a particular test, the reason for the fluctuation shall be determined, the cause corrected, and the test continued or repeated.

5.3.6* Pressure Control Test.

5.3.6.1 The pressure control device shall be tested at rated capacity at 150 psi (10 bar) net pump pressure as follows.

5.3.6.1.1 The pump shall be delivering rated capacity at 150 psi (10 bar) net pump pressure.

5.3.6.1.2 The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 150 psi (10 bar) net pump pressure.

5.3.6.1.3* All discharge valves shall be closed no more rapidly than in 3 seconds and no more slowly than in 10 seconds.

5.3.6.1.4 The rise in discharge pressure shall not exceed 30 psi (2 bar).

5.3.6.2 The pressure control device shall be tested at 90 psi (6.2 bar) net pump pressure as follows.

5.3.6.2.1 The original conditions of pumping rated capacity at 150 psi (10 bar) net pump pressure shall be reestablished.

5.3.6.2.2 The discharge pressure shall be reduced to 90 psi (6.2 bar) net pump pressure by throttling the engine fuel supply with no change to the discharge valve setting, hose, or nozzles.

5.3.6.2.3 The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 90 psi (6.2 bar) net pump pressure.

5.3.6.2.4 All discharge valves shall be closed no more rapidly than in 3 seconds and no more slowly than in 10 seconds.

5.3.6.2.5 The rise in discharge pressure shall not exceed 30 psi (2 bar).

5.3.6.3 The pressure control device shall be tested at 50 percent of rated capacity at 250 psi (17 bar) net pump pressure as follows.

5.3.6.3.1 The pump shall be delivering 50 percent of rated capacity at 250 psi (17 bar) net pump pressure.

5.3.6.3.2 The pressure control device shall be set in accordance with the manufacturer's instructions to maintain the discharge at 250 psi (17 bar) net pump pressure.

5.3.6.3.3 All discharge valves shall be closed no more rapidly than in 3 seconds and no more slowly than in 10 seconds.

5.3.6.3.4 The rise in discharge pressure shall not exceed 30 psi (2 bar).

5.3.7* Intake Relief Valve System Test. If the apparatus is equipped with an intake relief valve system or a combination intake/discharge system, a test to ensure the system is operating in accordance with the manufacturer's specifications shall be conducted.

5.3.8 Gauge Test.

5.3.8.1* Each water pressure gauge shall be checked for accuracy at a minimum of 3 points, including 150 psi (10 bar), 200 psi (14 bar), and 250 psi (17 bar).

5.3.8.2 Any gauge that is off by more than 10 psi (0.7 bar) shall be recalibrated, repaired, or replaced.

5.3.9 Flowmeter Test.

5.3.9.1 Each flowmeter shall be checked for accuracy at the test flows shown in Table 5.3.9.1.

Table 5.3.9.1 Flow-Measuring Points for Flowmeters

Pipe Size		Test Flow	
in.	**mm**	**gpm**	**L/min**
1	38	128	454
2	51	180	682
2½	65	300	1135
3	76	700	2650
4	100	1000	3785

5.3.9.2 Any flowmeter that is off by more than 10 percent shall be recalibrated, repaired, or replaced.

5.3.10 Tank-to-Pump Flow Rate. If the apparatus is equipped with a water tank, the tank-to-pump flow rate also shall be checked using the following procedure:

(1) The water tank shall be filled until it overflows.
(2) All intakes to the pump shall be closed.
(3) The tank fill line and bypass cooling line shall be closed.
(4) Hose lines and nozzles for discharging water at the anticipated flow rate shall be connected to one or more of the discharge outlets.
(5) The tank to the pump valve(s) and the discharge valves leading to the hose lines and nozzles shall be fully opened.
(6) The engine throttle shall be adjusted until the maximum consistent pressure reading on the discharge pressure gauge is obtained.
(7) The discharge valve(s) shall be closed and the water tank refilled. The bypass line shall be permitted to be opened temporarily if needed to keep the water temperature in the pump within acceptable limits.
(8) The discharge valves shall be reopened fully and a pitot reading or other flow measurement shall be taken while the water is being discharged. If necessary, the engine throttle shall be adjusted to maintain the discharge pressure noted in (6).
(9)*The flow rate shall be recorded and compared with the rate designated by the manufacturer when the apparatus was new or with the rate established in previous testing.

5.4* Test Results.

5.4.1* The pumping system (i.e., engine, pump, transmission) shall not overheat, lose power, or exhibit other defects during the entire test.

5.4.2 The flow rate, discharge pressure, intake pressure, and engine speed recorded for each test shall be the average of the readings taken during that test.

5.4.3* The results of all tests of the pump system shall be recorded, and the results shall be compared with the results of previous tests. Indications of decreasing pump or component performance shall be reported to the authority having jurisdiction.

5.4.4 Data that are 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.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.3 Investigation has shown that where regular and systematic tests of pumps are not made, defects often exist and can continue undetected for considerable periods under the light demands at ordinary fires; these defects 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. The breakdown of a pump at a fire or the inability of the crew to operate it properly can cause 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 complying difficult, alternative means for complying should be found (e.g., drafting pits).

A.3.2.1 Approved. 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, 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 that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, 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, or 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 or her 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.

A.3.3.1 Automatic Electrical Load Management System. Shedding of the loads occurs without human intervention but is capable of being manually overridden.

A.3.3.2 Compound Gauge. On most gauges, zero equals atmospheric pressure. Gauges typically measure pressure above atmospheric pressure in pounds per square inch (psi) and below atmospheric pressure in inches of mercury (Hg).

A.3.3.10.5 Net Pump Pressure. When the pump is operating from a hydrant, the net pump pressure typically is less than the discharge pressure. For example, if the discharge pressure gauge reads 150 psi (10 bar) and the intake (suction) gauge reads 20 psi (1.4 bar), the net pump pressure equals 130 psi (8.6 bar). When the pump is operating from draft, the net pump pressure will be above the discharge pressure. For example, if the discharge pressure gauge reads 145 psi (10 bar) and the intake (suction) gauge reads 10 in. of mercury (Hg) (0.34 bar) vacuum, the net pump pressure will be 150 psi (10.34 bar) (1 in. Hg = 0.5 psi = 0.034 bar).

A.3.3.11 Rated Capacity. Most fire pumps were certified to the requirements in the edition of NFPA 1901, *Standard for Automotive Fire Apparatus,* that was in effect on the date of manufacture.

A.3.3.13 Vacuum. Typically, vacuum is expressed in inches of mercury (Hg).

A.4.1.1 It is preferable to test apparatus at draft. 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 ft to 8 ft (1.2 m 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 (0.6 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 particles from the stream bed being drawn into the hose. 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.4.1.2 Testing the pump at draft is preferable to testing from a hydrant. The true performance of the pump is easier to evaluate while pumping from draft. If no suitable drafting site is available, testing the pump from a hydrant is acceptable. Care must be taken to ensure that the discharge gauge readings reflect the pressure necessary for the pump to be performing at the needed net pump pressure. For example, if the intake pressure gauge reads 30 psi and the test requires a 150 psi net pump pressure, the discharge test gauge should read 180 psi.

A.4.2 If conditions are not within the specified limits, the test should be delayed until they are satisfactory; otherwise, the results will need to be 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). If this criterion is not met, the pump performance could be affected seriously.

A.4.3.1.1 Table 4.3.1.1.1(a) and Table 4.3.1.1.2(a) show the suction hose size and number of suction lines to be used for testing at elevations up to 2000 ft (600 m). For elevations greater than 2000 ft, suction hose size and quantity might have to be increased to maintain the desired pump performance.

A.4.3.2.1 A flow velocity of 35 ft/sec (10.7 m/sec) is equal to approximately 500 gpm (2000 L/min) flowing through 2½ in. (65 mm) hose.

Table A.4.3.2.1 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 purpose of the hose is to convey water from the discharge side of the pump to the nozzle, monitor, or flow-measuring device where the volume will be measured and the water will be discharged to atmosphere. Single or multiple, larger diameter hose lines can be used for this purpose as well. The length and size of the hose are not factors unless the length and size together create excessive friction loss that requires the pump to operate above the net pump pressure that is required for the test to achieve the rated flow. If relatively short lengths of hose are used, total friction loss that is necessary to reduce the pump discharge pressure to the required nozzle pressure can be increased by partially closing the discharge valves on the apparatus.

For the protection of the operator, hose lines should not be connected to the pump at the operator's position. The hose that is used should be "attack hose" as defined by NFPA 1961, *Standard on Fire Hose*, and should have been recently tested in accordance with NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles.*

A.4.3.3.2 Nozzles that are suitable for testing usually can 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 could be erroneous. The actual coefficient of discharge needs to be determined by tests conducted by competent persons who are using equipment such as weigh tanks or calibrated flowmeters. Nozzles should be used with portable or mounted monitors. Hand-held nozzles should not be used.

The size of the nozzle that is used usually is chosen to give the desired discharge at a nozzle pressure between 60 psi and 70 psi (4.1 bar and 4.8 bar). 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 that is used at low pressure would come into play. Nozzle (pitot) pressures less than 50 psi (3.5 bar) or higher than 100 psi (6.9 bar) should be avoided. The nozzle should always be used in conjunction with a securely placed monitor; a test should never be conducted while any person holds the nozzle. Failure to abide by this precaution can cause serious injuries.

Only smoothbore nozzles should be used. Care should be taken that washers or gaskets do not protrude into the nozzle

Table A.4.3.2.1 Hose and Nozzle Layout Suggestions

Discharge (gpm)	Hose and Nozzle Layout
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 2¼-in. nozzle, or two 100-ft lines into 1¾-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.

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 made ready for the test, to ensure that there is no mistake about the size of the tip being used.

A.4.3.3.2.2 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 can be of several suitable types; the type shown in Figure A.4.3.3.2.2(a) can be readily constructed of brass and should be finished smooth. It should be connected by brass or other nonferrous metal pipe fittings to an air chamber and pressure gauge as shown in Figure A.4.3.3.2.2(b). A typical commercially available style is shown in Figure A.4.3.3.2.2(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.4.3.3.2.2(a), will get battered in service and need to 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. The proper position is in the center of the stream with the end of the tube away from the end of the nozzle by a distance that is equal to half of the nozzle diameter. A mechanical device might be desirable to hold the pitot tube rather than holding it by hand *[see Figure A.4.3.3.2.2(d)]*.

See Annex B, Table B.3(a), Table B.3(b), Table B.3(c), and Table B.3(d), for information on determination of flow rates with nozzles.

A.4.3.4.1 It is important that gauges be sufficiently accurate to ensure that test results are reliable. Grade A gauges per ASME B40.100, *Pressure Gauges and Gauge Attachments*, 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 (0–28 bar) gauge will be accurate within 4 psi (0.28 bar) from 100 psi to 300 psi (7 bar to 21 bar). 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.

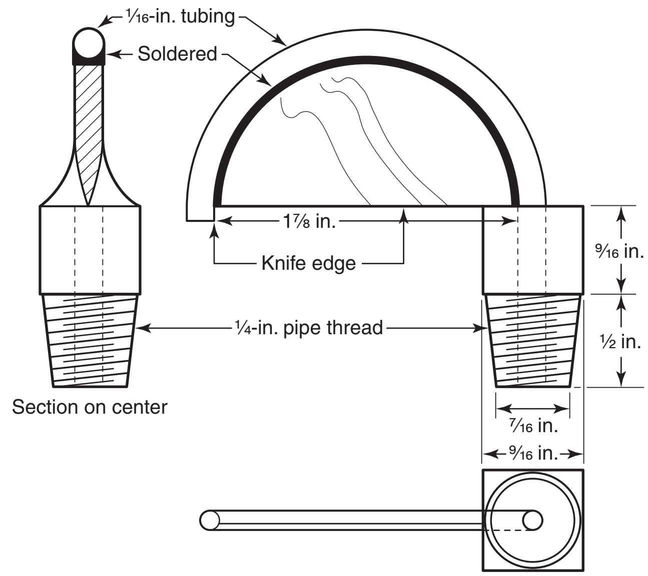

FIGURE A.4.3.3.2.2(a) Nozzle Stream Pitot Tube.

While a 0–400 psi (0–28 bar) range is not preferred per ASME B40.100, 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 (0.3 bar maximum on a 0–28 bar Grade A gauge)], and smaller increments are recommended. Many variations and special constructions are available, and gauge manufacturers can be contacted for their recommendations.

A.4.3.5 If a counter speed shaft is not provided, the engine speed can be read with a photo-tachometer or strobe light off a rotating element.

A.5.1 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 so as to require assurance after the repair that the pump is still operating properly.

A.5.2 It is recommended that the fire department duplicate the test conditions to the extent possible from year to year to allow more accurate comparison of data over a period of time. These conditions should include the following: lift; atmospheric pressure; air and water temperature; suction hose size, length, and style; strainer type; and intake and discharge hose layout.

A.5.2.3 The engine compartment should remain closed during the pumping test unless the apparatus was designed to an older standard that permitted testing with the compartment open.

A.5.3.1 Other data that should be obtained are indicated on the test form shown as Figure A.5.4. The layout of the hose and nozzle and data about the pump and engine should be recorded.

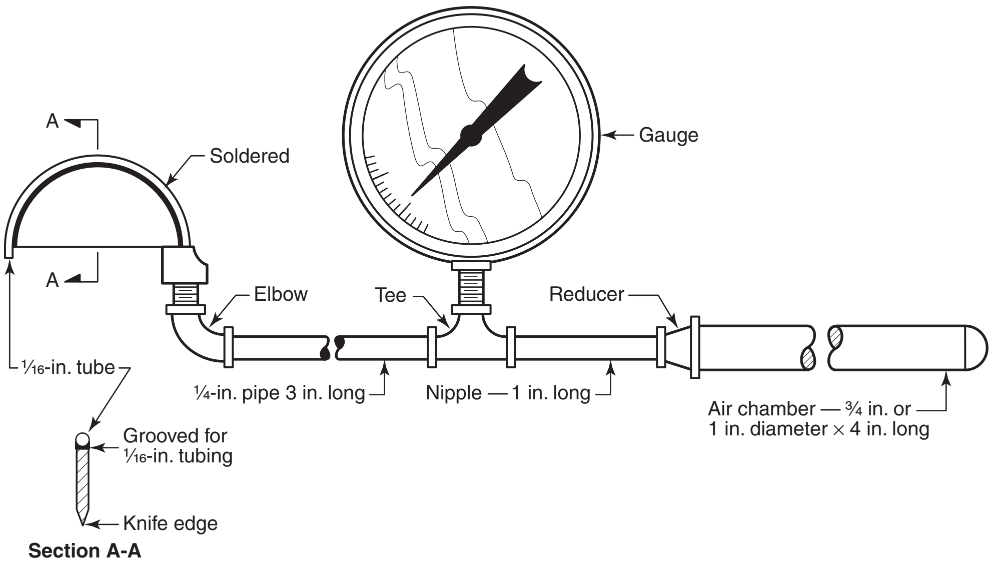

FIGURE A.4.3.3.2.2(b) Pitot Tube Assembly.

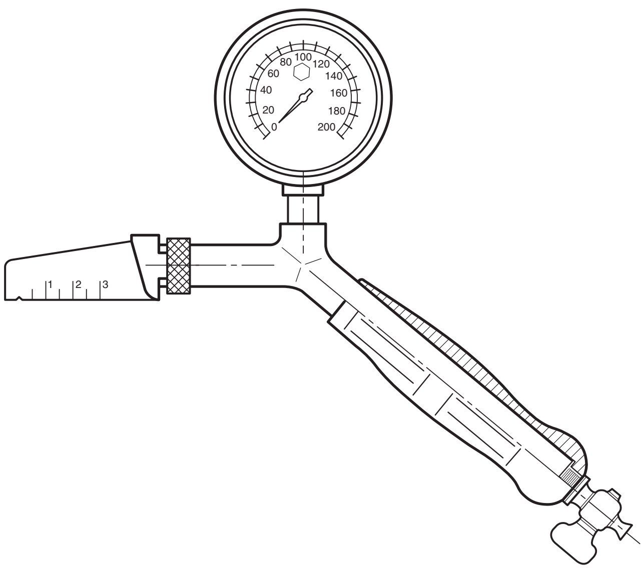

FIGURE A.4.3.3.2.2(c) Commercial Pitot Tube.

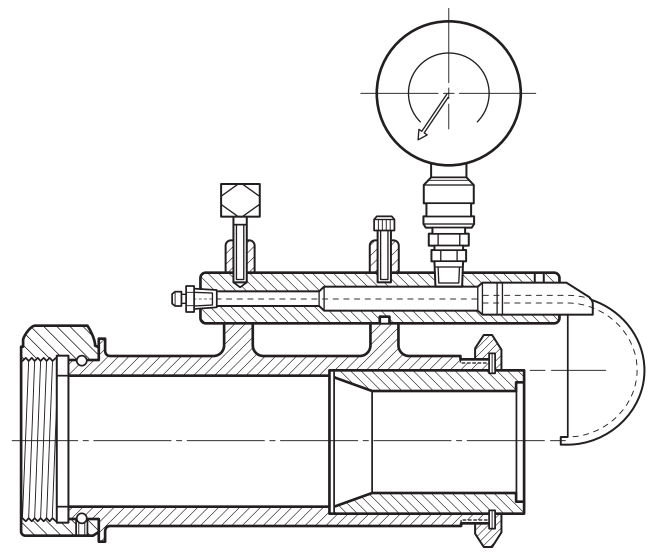

FIGURE A.4.3.3.2.2(d) Pitot Tube Attached to Nozzle.

A.5.3.4 At the time of purchase, a pump must be able to develop a vacuum of 22 in. of mercury (Hg) (0.75 bar) with a capped suction hose and must hold the vacuum with a drop not in excess of 10 in. Hg (0.34 bar) in 5 minutes. 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 number, length, and condition of suction hose, as well as altitude, water temperature, atmospheric pressure, and lift, are all factors that affect pumping from draft.

A.5.3.5.4 If the pump is a two-stage, parallel/series-type unit, then operation of the transfer (i.e., changeover) valve should be checked thoroughly. Conducting the pumping test with the transfer valve positioned as specified in 5.3.5.4 will ensure that the valve is exercised. If a comparison with the original engine speeds shows a significant difference for any of the tests, one of the problems could be with the transfer valve.

A.5.3.6 Care should be taken to perform the pressure control tests using net pump pressure and net pressure rise readings. Some pressure control systems might not operate correctly if the hydrant pressure is too high; the system manufacturer's manual should be consulted for information.

A.5.3.6.1.3 Closing all discharges in less than 3 seconds could cause instantaneous pressure rises that the pressure control device might not be able to respond to rapidly enough to avoid damage to the pumping system. Taking more than 10 seconds to close the discharges is not a reasonable test of the pressure control device response capability. Controlling closure of the discharges can be done manually or otherwise.

A.5.3.7 One method of conducting this test is to use a second pumping apparatus to supply water to the pump being tested. Pressure from the supply pump should be increased until the receiving pump relief system opens a dump valve. The pressure at which the system opens, dumps, or otherwise starts to operate should be recorded. The pressure at which the system starts to operate should be reviewed against current operating procedures and the system adjusted accordingly.

A.5.3.8.1 Pressure gauges can be checked quickly 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.

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

A.5.3.10(9) Rates less than the rate when the apparatus was new or as established in previous testing indicate problems in the tank-to-pump line or tank.

A.5.4 Some test data forms for recording the test readings and other necessary data should be provided. Figure A.5.4 provides an example of a suitable form. The use of such a form will help to ensure that all needed data are obtained.

A.5.4.1 When operating at or near full engine power while stationary, the generated heat can 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.

Normal wear in the pumping system can require speeds greater than those required at the time of delivery for the pumping test. Such variances are acceptable as long as the apparatus passes the pumping test without exceeding the governed engine speed.

A.5.4.3 If the test conditions are equal to those at the time of delivery of the apparatus and the speed of the engine increases by more than 10 percent of the original engine speed, the reason for the decrease in performance should be determined and the deficiency corrected. Where test conditions are significantly different from the original test conditions at the time of delivery, results should be compared with previous years' tests. The test conditions should be maintained as consistent as possible from test period to test period.

SERVICE TEST RESULTS

Apparatus number or designation: ______________________________

Manufacturer: ______________________ Year manufactured: ______________

Manufacturer's model: ______________________ Serial number: ______________

Engine make: ______________________ Model: ______________________

Pump make: ______________________ Model: ______________________

Pump rated capacity: __________(gpm) (L/min) at __________ (psi) (bar)

Speed check taken from: ______________________ Ratio to engine: ______________

Test site location: ______________________________

Tests performed from ❑ Draft ❑ Hydrant

Suction hose size: ________ (in.) (mm) Length: ________ (ft) (m)

	At start of tests	At end of tests
Atmospheric pressure		
Air temperature		
Water temperature		
Elevation of test site		
Lift		

Governed engine speed: ______________ Actual maximum engine speed: ______________

Maximum vacuum attained: ______________ Vacuum drop in 5 minutes: ______________

Time to prime pump: ______________________

Pressure control device test:

Rise while pumping capacity at 150 psi: ______________________

Rise while pumping capacity at 90 psi: ______________________

Rise while pumping 50 percent capacity at 250 psi: ______________________

Intake relief valve test results: ______________________________

Tank-to-pump water flow test: ______________________ (gpm) (L/min)

Gauge accuracy: ______________________ Flowmeter accuracy: ______________________

PUMP TEST RESULTS

	Capacity test	Overload test	200 psi test	250 psi test
Duration				
Average nozzle pressure				
Corrected pressure				
Gallons per minute				
Average pump pressure				
Rpm — engine				
Rpm — pump				

Remarks: ______________________________

____

Witnessed by: ______________________ Date: ______________________

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FIGURE A.5.4 Test Data Form.

20-MINUTE CAPACITY TEST

Layout: ____ Nozzle size: _________ Position of transfer valve: ______________________

								Pump Intake		Pump Discharge		
Time	Counter (if used)	Rpm	Tach	Engine Temp.	Oil Pressure	Voltage	Automatic Transmission Temp. (if equipped)	Apparatus Gauge	Test Gauge	Apparatus Gauge	Test Gauge	Pitot/Flow

5-MINUTE OVERLOAD TEST

10-MINUTE 200 PSI TEST

Layout: ____ Nozzle size: _________ Position of transfer valve: _____________

10-MINUTE 250 PSI TEST

Layout: ____ Nozzle size: _________ Position of transfer valve: _____________

(NFPA 1911, 2 of 2)

FIGURE A.5.4 *Continued*

Annex B Conducting Pumping Tests

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Test Parameters. At the start of the test, attention should be paid to the ease with which the pump can develop a vacuum. Before starting to prime the pump, close all discharge, drain, and water tank valves and petcocks; make sure that the gaskets in the suction hose are in place and free of foreign matter; open all intake valves; and tighten all intake caps and couplings.

Start the priming mechanism, noting the starting time and the time after prime is obtained. The starting time is defined as the instant the priming device begins to operate. The pump is considered primed when water under pressure has entered a discharge hose. For pumps of less than 1500 gpm (6000 L/min), the priming device should be able to create the necessary vacuum in 30 seconds to lift water 10 ft (3 m) through 20 ft (6 m) of suction hose of the appropriate size. The priming device on pumps of 1500 gpm (6000 L/min) or larger should be able to accomplish this in 45 seconds. An additional 15 seconds might be needed where the pump system includes an auxiliary 4-in. (100-mm) or larger intake pipe having a volume of 1 ft^3 (28,317 cm^3) or more. Operate the controls as necessary to develop pressure, and then open one discharge valve to allow the flow of water.

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

The pump should be operated at reduced capacity and pressure for several minutes to allow the engine and transmission to warm up. Gradually, the pump speed should be increased until the desired pressure at the pump is reached. If the desired pressure is not attained, a length or two of hose might 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 can be increased by further speeding up the pump; but if speeding up the pump increases the pump pressure more than 5 psi or 10 psi (0.34 bar or 0.68 bar), a length of hose should be taken out, a discharge valve should be opened slightly, or a larger nozzle should be used.

A speed reading should be taken at frequent intervals, corresponding to the time that the pressure readings were taken. Counting the revolutions for 1 minute generally ensures that readings will be sufficiently accurate.

When a stopwatch is used, 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 1 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 ("snubber") in the line to the gauge can be throttled to prevent excessive vibration, but if the valve is throttled too much, the gauge pointer will no longer indicate the pressure correctly. It might not be possible to eliminate all of the pointer movement. Leaks in the line to the test gauge also can 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 increased erroneously.

Short lines of hose are always more convenient for a test layout than long ones. Generally, it is better to use a single line of 100 ft (30 m) for the pressure tests and to 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 gradually can be 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 lubricated properly. 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 is 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.

B.2 Troubleshooting. 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 could 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 reason for the failure 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 the maximum vacuum that is 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 in. (254 mm) or more in less than 5 minutes, there is a leak in the suction hose or pump assembly; it could be in a valve, draincock, piping, casing, or pump packing. The leakage might 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 intake arrangement. Insufficient power is indicated by the inability of the engine to reach the required speed for the desired pumping condition. Some possible causes of insufficient power are as follows: the operator might have failed to advance the throttle far enough or might be using the wrong transmission gear position; the engine might be in need of a tune-up; the grade of fuel might be improper for adequate combustion; or there might be vaporization in the fuel line.

Restriction in the intake arrangement is indicated if the pump speed is too high for the capacity and attained pressure levels and could be the result of any one or combination of the following conditions:

(1) Suction hose is too small.
(2) Altitude is too high.
(3) Lift is too high.
(4) Strainer type is incorrect.
(5) Intake strainer is clogged at the pump or at the end of the suction hose.
(6) Water is aerated.
(7) Water is too warm [above 90°F (32°C)].
(8) Suction hose is collapsed or defective.
(9) Foreign material is in pump.

An air leak in the suction hose connections or in the pump intake manifold also will result in excessive pump speed and eventually could cause loss of prime and complete cessation of flow.

Insufficient pressure when operating a centrifugal pump could be the result of pumping too much water for the available power and, in multistage pumps, pumping in "volume" position instead of the required "pressure" position. This problem 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 can prevent the development of adequate pressure. Likewise, the pressure control system might be set too low or be defective.

Engine speed differences from the original pump test could be the result of any one or combination of the following conditions:

(1) Operating the apparatus with the wrong transmission gear in use
(2) Stuck or out-of-adjustment throttle control system
(3) Restrictions in the intake arrangement
(4) Suction hose under an insufficient depth of water
(5) Air leak on the intake side of the pump
(6) Changes in environmental conditions
(7) Pump or engine wear

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.

B.3 Calculating the Results. If nozzles and pitot tubes have been used to measure pump capacity, the values of capacity in gallons per minute are determined by the following formula:

$$\text{gpm} = 29.83\ c(d)^2 \sqrt{p}$$

where:
c = coefficient of discharge of the nozzle used
d = diameter of nozzle (in.)
p = pressure of pitot gauge (psi)

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

For nozzles sized from ¼ in. (6.3 mm) to 2¼ in. (57 mm), values of capacity can be approximated from Table B.3(a), Table B.3(b), Table B.3(c), and Table B.3(d); however, as these values are based on certain assumed coefficients of discharge, they can be considerably at variance with the actual values. For nozzles larger than 2¼ in. (57 mm), approximate values of capacity can be obtained from Table B.3(e).

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

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

where:
F = factor from the table
p = pressure at pitot gauge in psi

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, which include the following:

(1) Design of the pump
(2) Adequacy of the engine
(3) Condition of pump and engine
(4) Size and condition of suction hose and strainers
(5) Elevation of the pumping site above sea level
(6) Atmospheric pressure
(7) 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 1 in. of mercury is equal to a negative pressure of 0.49 psi; or 1 in. Hg = 0.49 psi. A positive pressure of 0.49 psi at the bottom of a 1-in.^{2} container will support a column of water that is 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.