NFPA®

291

Recommended Practice for Fire Flow Testing and Marking of Hydrants

2019

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NFPA® 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

2019 Edition

This edition of NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, was prepared by the Technical Committee on Private Water Supply Piping Systems and released by the Correlating Committee on Automatic Sprinkler Systems. It was issued by the Standards Council on May 4, 2018, with an effective date of May 24, 2018, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 291 was approved as an American National Standard on May 24, 2018.

Origin and Development of NFPA 291

The NFPA Committee on Public Water Supplies for Private Fire Protection presented the idea of indicating the relative available fire service water supply from hydrants in its 1934 report. The committee felt then and feels now that such an indication is of substantial value to water and fire departments. The following recommendations were initially adopted in 1935. The committee agreed that tests of individual hydrants did not give as complete and satisfactory results as group testing but expressed the opinion that tests of individual hydrants did have sufficient value to make the following recommendations worthy of adoption. This was reconfirmed with minor editorial changes in 1974.

The 1977 edition was completely rewritten and a chapter on the flow testing of hydrants was added.

The 1982 edition was reconfirmed by the committee.

The 1988 edition of the document noted several changes that clarified and reinforced certain recommendations. Specific guidance was added on the correct method of using a pitot tube to gain accurate test results.

The 1995 edition incorporated several changes in an attempt to make the document more user-friendly. Changes were also incorporated with regard to the layout of hydrant and water flow tests.

The 2002 edition clarified the recommendations for flow tests and was restructured to comply with the *Manual of Style for NFPA Technical Committee Documents*.

The 2007 edition represented a reconfirmation of the 2002 edition, as there were no technical changes.

The 2010 edition clarified the responsibility for marking of hydrants.

The 2013 edition of NFPA 291 added language recommending frequencies for flushing and flow testing of public hydrants in Section 4.13.

No technical revisions were made to the 2016 edition of NFPA 291.

The 2019 edition of NFPA 291 includes the metric formula for discharge through circular orifices, and the table on discharge through circular orifices has been updated to provide measurable velocity pressures in the metric system.

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Committee Scope: This Committee shall have the primary responsibility for documents on private piping systems supplying water for fire protection and for hydrants, hose houses, and valves. The Committee is also responsible for documents on fire flow testing and marking of hydrants.

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Recommended Practice for

Fire Flow Testing and Marking of Hydrants

2019 Edition

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Information on referenced publications can be found in Chapter 2.

Chapter 1 Administration

1.1 Scope. The scope of this document is fire flow testing and marking of hydrants.

1.2 Purpose. Fire flow tests are conducted on water distribution systems to determine the rate of flow available at various locations for fire-fighting purposes.

1.3 Application. A certain residual pressure in the mains is specified at which the rate of flow should be available. Additional benefit is derived from fire flow tests by the indication of possible deficiencies, such as tuberculation of piping or closed valves or both, which could be corrected to ensure adequate fire flows as needed.

1.4 Units. Metric units of measurement in this recommended practice are in accordance with the modernized metric system known as the International System of Units (SI). Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1.4 with conversion factors.

Δ Table 1.4 SI Units and Conversion Factors

Unit Name	Unit Symbol	Conversion Factor
Liter	L	1 gal = 3.785 L
Liter per minute per square meter	$(L/min)/m^2$	1 gpm ft^2 = $(40.746\ L/min)/m^2$
Cubic decimeter	dm^3	1 gal = 3.785 dm^3
Pascal	Pa	1 psi = 6894.757 Pa
Bar	bar	1 psi = 0.0689 bar
Bar	bar	1 bar = 10^5 Pa

Note: For additional conversions and information, see IEEE/ASTM-SI-10, *Standard for Use of the International System of Units (SI): The Modern Metric System,* 2010.

1.4.1 If a value for measurement as given in this recommended practice is followed by an equivalent value in other units, the first value stated is to be regarded as the recommendation. A given equivalent value might be approximate.

Chapter 2 Referenced Publications

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

2.2 NFPA Publications. (Reserved)

2.3 Other Publications.

2.3.1 IEEE Publications. IEEE, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE/ASTM-SI-10, *Standard for Use of the International System of Units (SI): The Modern Metric System,* 2010.

2.3.2 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Recommendations Sections. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter apply to the terms used in this recommended practice. Where terms are not defined in this chapter or within another chapter, they should be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, is the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.2* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

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

3.3 General Definitions.

3.3.1 Rated Capacity. The flow available from a hydrant at the designated residual pressure (rated pressure), either measured or calculated.

3.3.2 Residual Pressure. The pressure that exists in the distribution system, measured at the residual hydrant at the time the flow readings are taken at the flow hydrants.

3.3.3 Static Pressure. The pressure that exists at a given point under normal distribution system conditions measured at the residual hydrant with no hydrants flowing.

Chapter 4 Flow Testing

4.1 Rating Pressure.

4.1.1 For the purpose of uniform marking of fire hydrants, the ratings should be based on a residual pressure of 20 psi (1.4 bar) for all hydrants having a static pressure in excess of 40 psi (2.7 bar).

4.1.2 Hydrants having a static pressure of less than 40 psi (2.7 bar) should be rated at one-half of the static pressure.

4.1.3 It is generally recommended that a minimum residual pressure of 20 psi (1.4 bar) should be maintained at hydrants when delivering the fire flow. Fire department pumpers can be operated where hydrant pressures are less, but with difficulty.

4.1.4 Where hydrants are well distributed and of the proper size and type (so that friction losses in the hydrant and suction line are not excessive), it might be possible to set a lesser pressure as the minimum pressure.

4.1.5 A primary concern should be the ability to maintain sufficient residual pressure to prevent developing a negative pressure at any point in the street mains, which could result in the collapse of the mains or other water system components or back-siphonage of polluted water from some other interconnected source.

4.1.6 It should be noted that the use of residual pressures of less than 20 psi (1.4 bar) is not permitted by many state health departments.

4.2 Procedure.

4.2.1 Tests should be made during a period of ordinary demand.

4.2.2 The procedure consists of discharging water at a measured rate of flow from the system at a given location and observing the corresponding pressure drop in the mains.

4.3 Layout of Test.

4.3.1 After the location where the test is to be run has been determined, a group of test hydrants in the vicinity is selected.

4.3.2 Once selected, due consideration should be given to potential interference with traffic flow patterns, damage to surroundings (e.g., roadways, sidewalks, landscapes, vehicles, and pedestrians), and potential flooding problems both local and remote from the test site.

4.3.3 One hydrant, designated the residual hydrant, is chosen to be the hydrant where the normal static pressure will be observed with the other hydrants in the group closed, and where the residual pressure will be observed with the other hydrants flowing.

4.3.4 This hydrant is chosen so it will be located between the hydrant to be flowed and the large mains that constitute the immediate sources of water supply in the area. In Figure 4.3.4, test layouts are indicated showing the residual hydrant designated with the letter R and hydrants to be flowed with the letter F.

4.3.5 The number of hydrants to be used in any test depends upon the strength of the distribution system in the vicinity of the test location.

4.3.6 To obtain satisfactory test results of theoretical calculation of expected flows or rated capacities, sufficient discharge should be achieved to cause a drop in pressure at the residual hydrant of at least 25 percent, or to flow the total demand necessary for fire-fighting purposes.

4.3.7 If the mains are small and the system weak, only one or two hydrants need to be flowed.

4.3.8 If, on the other hand, the mains are large and the system strong, it may be necessary to flow as many as seven or eight hydrants.

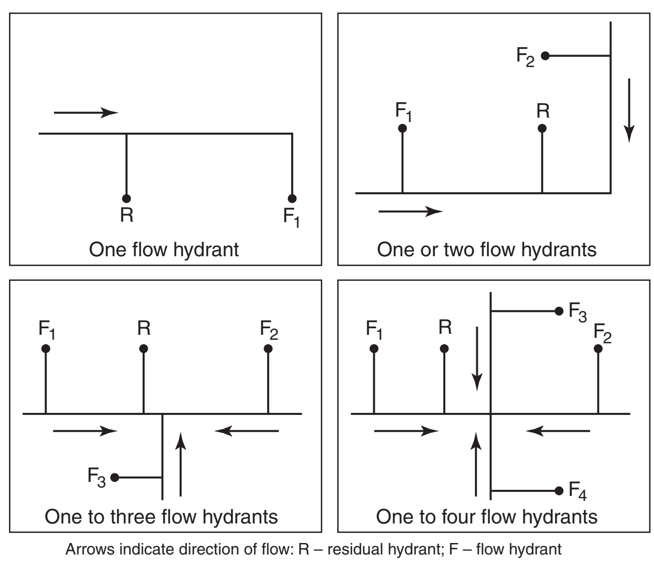


FIGURE 4.3.4 Suggested Test Layout for Hydrants.

4.4 Equipment.

4.4.1 The equipment necessary for field work consists of the following:

(1) A single 200 psi (14 bar) bourdon pressure gauge with 1 psi (0.07 bar) graduations
(2) A number of pitot tubes
(3) Hydrant wrenches
(4) 50 or 60 psi (3.4 or 4.1 bar) bourdon pressure gauges with 1 psi (0.07 bar) graduations, and scales with 1⁄16 in. (1.6 mm) graduations [one pitot tube, a 50 or 60 psi (3.4 or 4.1 bar) gauge, a hydrant wrench, a scale for each hydrant to be flowed]
(5) A special hydrant cap tapped with a hole into which is fitted a short length of 1⁄4 in. (6 mm) brass pipe provided with a T connection for the 200 psi (14 bar) gauge and a cock at the end for relieving air pressure

4.4.2 All pressure gauges should be calibrated at least every 12 months, or more frequently depending on use.

4.4.3 When more than one hydrant is flowed, it is desirable and could be necessary to use portable radios to facilitate communication between team members.

4.4.4 It is preferred to use stream straightener with a known coefficient of discharge when testing hydrants due to a more streamlined flow and more accurate pitot reading.

4.5 Test Procedure.

4.5.1 In a typical test, the 200 psi (14 bar) gauge is attached to one of the 2½ in. (65 mm) outlets of the residual hydrant using the special cap.

4.5.2 The cock on the gauge piping is opened, and the hydrant valve is opened full.

4.5.3 As soon as the air is exhausted from the barrel, the cock is closed.

4.5.4 A reading (static pressure) is taken when the needle comes to rest.

4.5.5 At a given signal, each of the other hydrants is opened in succession, with discharge taking place directly from the open hydrant butts.

4.5.6 Hydrants should be opened one at a time.

4.5.7 With all hydrants flowing, water should be allowed to flow for a sufficient time to clear all debris and foreign substances from the stream(s).

4.5.8 At that time, a signal is given to the people at the hydrants to read the pitot pressure of the streams simultaneously while the residual pressure is being read.

4.5.9 The final magnitude of the pressure drop can be controlled by the number of hydrants used and the number of outlets opened on each.

4.5.10 After the readings have been taken, hydrants should be shut down slowly, one at a time, to prevent undue surges in the system.

4.6 Pitot Readings.

4.6.1 When measuring discharge from open hydrant butts, it is always preferable from the standpoint of accuracy to use 2½ in. (65 mm) outlets rather than pumper outlets.

4.6.2 In practically all cases, the 2½ in. (65 mm) outlets are filled across the entire cross-section during flow, while in the case of the larger outlets there is very frequently a void near the bottom.

4.6.3 When measuring the pitot pressure of a stream of practically uniform velocity, the orifice in the pitot tube is held downstream approximately one-half the diameter of the hydrant outlet or nozzle opening, and in the center of the stream.

4.6.4 The center line of the orifice should be at right angles to the plane of the face of the hydrant outlet.

4.6.5 The air chamber on the pitot tube should be kept elevated.

4.6.6 Pitot readings of less than 10 psi (0.7 bar) and more than 30 psi (2.1 bar) should be avoided, if possible.

4.6.7 Opening additional hydrant outlets will aid in controlling the pitot reading.

4.6.8 With dry barrel hydrants, the hydrant valve should be wide open to minimize problems with underground drain valves.

4.6.9 With wet barrel hydrants, the valve for the flowing outlet should be wide open to give a more streamlined flow and a more accurate pitot reading. *(See Figure 4.6.9.)*

4.7 Determination of Discharge.

4.7.1 At the hydrants used for flow during the test, the discharges from the open butts are determined from measurements of the diameter of the outlets flowed, the pitot pressure (velocity head) of the streams as indicated by the pitot gauge readings, and the coefficient of the outlet being flowed as determined from Figure 4.7.1.

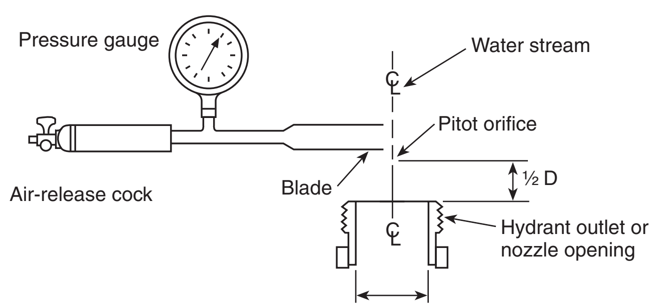


FIGURE 4.6.9 Pitot Tube Position.

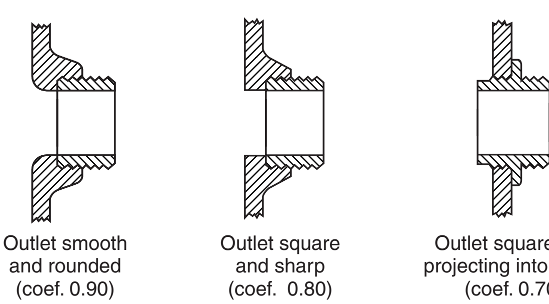


FIGURE 4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.

4.7.2 If flow tubes (stream straighteners) are being utilized, a coefficient of 0.95 is suggested unless the coefficient of the tube is known.

4.7.3 The formula used to compute the discharge, Q, in gpm (L/min) from these measurements is as shown in Equations 4.7.3a and 4.7.3b.

[4.7.3a]

$$Q = 29.84cd^2\sqrt{p}$$

where:
Q = flow (gpm)
c = coefficient of discharge (*see Figure 4.7.1*)
d = diameter of the outlet (in.)
p = pitot pressure (velocity head) (psi)

N **[4.7.3b]**

$$Q_M = 0.666cd^2\sqrt{p_M}$$

where:
Q_M = flow (L/min)
c = coefficient of discharge (*see Figure 4.7.1*)
d = diameter of the outlet (mm)
p_M = pitot pressure (velocity head) (bar)

4.8 Use of Pumper Outlets.

4.8.1 If it is necessary to use a pumper outlet, and flow tubes (stream straighteners) are not available, the best results are obtained with the pitot pressure (velocity head) maintained between 5 psi and 10 psi (0.34 bar and 0.7 bar).

4.8.2 For pumper outlets, the approximate discharge can be computed from Equations 4.7.3a and 4.7.3b using the pitot pressure (velocity head) at the center of the stream and multiplying the result by one of the coefficients in Table 4.8.2, depending upon the pitot pressure (velocity head).

4.8.3 These coefficients are applied in addition to the coefficient in Equations 4.7.3a and 4.7.3b and are for average-type hydrants.

4.9 Determination of Discharge Without a Pitot.

4.9.1 If a pitot tube is not available for use to measure the hydrant discharge, a 50 or 60 psi (3.4 or 4.1 bar) gauge tapped into a hydrant cap can be used.

Table 4.8.2 Pumper Outlet Coefficients

Pitot Pressure (Velocity Head)		
psi	bar	Coefficient
2	0.14	0.97
3	0.21	0.92
4	0.28	0.89
5	0.35	0.86
6	0.41	0.84
7 and over	0.48 and over	0.83

4.9.2 The hydrant cap with gauge attached is placed on one outlet, and the flow is allowed to take place through the other outlet at the same elevation.

4.9.3 The readings obtained from a gauge so located, and the readings obtained from a gauge on a pitot tube held in the stream, are approximately the same.

4.10 Calculation Results.

Δ **4.10.1** The discharge in gpm (L/min) for each outlet flowed is obtained from Table 4.10.1(a) and Table 4.10.1(b) or by the use of Equations 4.7.3a and 4.7.3b.

4.10.1.1 If more than one outlet is used, the discharges from all are added to obtain the total discharge.

4.10.1.2 The formula that is generally used to compute the discharge at the specified residual pressure or for any desired pressure drop is Equation 4.10.1.2:

[4.10.1.2]

$$Q_R = Q_F \times \frac{h_r^{0.54}}{h_f^{0.54}}$$

where:
Q_R = flow predicted at desired residual pressure
Q_F = total flow measured during test
h_r = pressure drop to desired residual pressure
h_f = pressure drop measured during test

4.10.1.3 In Equation 4.10.1.2, any units of discharge or pressure drop can be used as long as the same units are used for each value of the same variable.

4.10.1.4 In other words, if Q_R is expressed in gpm, Q_F must be in gpm, and if h_r is expressed in psi, h_f must be expressed in psi.

4.10.1.5 These are the units that are normally used in applying Equation 4.10.1.2 to fire flow test computations.

4.10.2 Discharge Calculations from Table.

4.10.2.1 One means of solving this equation without the use of logarithms is by using Table 4.10.2.1, which gives the values of the 0.54 power of the numbers from 1 to 175.

4.10.2.2 If the values of h_f, h_r, and Q_F are known, the values of $h_f^{0.54}$ and $h_r^{0.54}$ can be read from Table 4.10.2.1 and Equation 4.10.1.2 solved for Q_R.

4.10.2.3 Results are usually carried to the nearest 100 gpm (380 L/min) for discharges of 1000 gpm (3800 L/min) or more, and to the nearest 50 gpm (190 L/min) for smaller discharges, which is as close as can be justified by the degree of accuracy of the field observations.

4.10.2.4 The values of $h_r^{0.54}$ and $h_f^{0.54}$ (determined from the table) and the value of Q_F are inserted in Equation 4.10.1.2, and the equation solved for Q_R.

4.11 Data Sheet.

4.11.1 The data secured during the testing of hydrants for uniform marking can be valuable for other purposes.

4.11.2 With this in mind, it is suggested that the form shown in Figure 4.11.2 be used to record information that is taken.

Δ Table 4.10.1(a) Theoretical Discharge Through Circular Orifices (U.S. Gallons of Water per Minute)

Pitot Pressure (psi)	Feet	Velocity Discharge (ft/sec)	Orifice Size (in.)											
			2	2.25	2.375	2.5	2.625	2.75	3	3.25	3.5	3.75	4	4.5
1	2.31	12.20	119	151	168	187	206	226	269	315	366	420	477	604
2	4.61	17.25	169	214	238	264	291	319	380	446	517	593	675	855
3	6.92	21.13	207	262	292	323	356	391	465	546	633	727	827	1047
4	9.23	24.39	239	302	337	373	411	451	537	630	731	839	955	1209
5	11.54	27.26	267	338	376	417	460	505	601	705	817	938	1068	1351
6	13.84	29.87	292	370	412	457	504	553	658	772	895	1028	1169	1480
7	16.15	32.26	316	400	445	493	544	597	711	834	967	1110	1263	1599
8	18.46	34.49	338	427	476	528	582	638	760	891	1034	1187	1350	1709
9	20.76	36.58	358	453	505	560	617	677	806	946	1097	1259	1432	1813
10	23.07	38.56	377	478	532	590	650	714	849	997	1156	1327	1510	1911
11	25.38	40.45	396	501	558	619	682	748	891	1045	1212	1392	1583	2004
12	27.68	42.24	413	523	583	646	712	782	930	1092	1266	1454	1654	2093
13	29.99	43.97	430	545	607	672	741	814	968	1136	1318	1513	1721	2179
14	32.30	45.63	447	565	630	698	769	844	1005	1179	1368	1570	1786	2261
15	34.61	47.22	462	585	652	722	796	874	1040	1221	1416	1625	1849	2340
16	36.91	48.78	477	604	673	746	822	903	1074	1261	1462	1679	1910	2417
17	39.22	50.28	492	623	694	769	848	930	1107	1300	1507	1730	1969	2491
18	41.53	51.73	506	641	714	791	872	957	1139	1337	1551	1780	2026	2564
19	43.83	53.15	520	658	734	813	896	984	1171	1374	1593	1829	2081	2634
20	46.14	54.54	534	676	753	834	920	1009	1201	1410	1635	1877	2135	2702
22	50.75	57.19	560	709	789	875	964	1058	1260	1478	1715	1968	2239	2834
24	55.37	59.74	585	740	825	914	1007	1106	1316	1544	1791	2056	2339	2960
26	59.98	62.18	609	770	858	951	1048	1151	1369	1607	1864	2140	2434	3081
28	64.60	64.52	632	799	891	987	1088	1194	1421	1668	1934	2220	2526	3197
30	69.21	66.79	654	827	922	1022	1126	1236	1471	1726	2002	2298	2615	3310
32	73.82	68.98	675	855	952	1055	1163	1277	1519	1783	2068	2374	2701	3418
34	78.44	71.10	696	881	981	1087	1199	1316	1566	1838	2131	2447	2784	3523
36	83.05	73.16	716	906	1010	1119	1234	1354	1611	1891	2193	2518	2865	3626
38	87.67	75.17	736	931	1038	1150	1268	1391	1656	1943	2253	2587	2943	3725
40	92.28	77.11	755	955	1065	1180	1300	1427	1699	1993	2312	2654	3020	3822
42	96.89	79.03	774	979	1091	1209	1333	1462	1740	2043	2369	2719	3094	3916
44	101.51	80.88	792	1002	1116	1237	1364	1497	1781	2091	2425	2783	3167	4008
46	106.12	82.70	810	1025	1142	1265	1395	1531	1821	2138	2479	2846	3238	4098
48	110.74	84.48	827	1047	1166	1292	1425	1563	1861	2184	2533	2907	3308	4186
50	115.35	86.22	844	1068	1190	1319	1454	1596	1899	2229	2585	2967	3376	4273
52	119.96	87.93	861	1089	1214	1345	1483	1627	1937	2273	2636	3026	3443	4357
54	124.58	89.61	877	1110	1237	1370	1511	1658	1974	2316	2686	3084	3508	4440
56	129.19	91.20	893	1130	1260	1396	1539	1689	2010	2359	2735	3140	3573	4522
58	133.81	92.87	909	1150	1282	1420	1566	1719	2045	2400	2784	3196	3636	4602
60	138.42	94.45	925	1170	1304	1445	1593	1748	2080	2441	2831	3250	3698	4681
62	143.03	96.01	940	1189	1325	1469	1619	1777	2115	2482	2878	3304	3759	4758
64	147.65	97.55	955	1209	1347	1492	1645	1805	2148	2521	2924	3357	3820	4834
66	152.26	99.07	970	1227	1367	1515	1670	1833	2182	2561	2970	3409	3879	4909
68	156.88	100.55	984	1246	1388	1538	1696	1861	2215	2599	3014	3460	3937	4983
70	161.49	102.03	999	1264	1408	1560	1720	1888	2247	2637	3058	3511	3995	5056
72	166.10	103.47	1013	1282	1428	1583	1745	1915	2279	2674	3102	3561	4051	5127
74	170.72	104.90	1027	1300	1448	1604	1769	1941	2310	2711	3144	3610	4107	5198
76	175.33	106.30	1041	1317	1467	1626	1793	1967	2341	2748	3187	3658	4162	5268
78	179.95	107.69	1054	1334	1487	1647	1816	1993	2372	2784	3228	3706	4217	5337
80	184.56	109.08	1068	1351	1505	1668	1839	2018	2402	2819	3269	3753	4270	5405

(continues)

Δ **Table 4.10.1(a)** ***Continued***

Pitot Pressure (psi)	Feet	Velocity Discharge (ft/sec)	Orifice Size (in.)											
			2	**2.25**	**2.375**	**2.5**	**2.625**	**2.75**	**3**	**3.25**	**3.5**	**3.75**	**4**	**4.5**
82	189.17	110.42	1081	1368	1524	1689	1862	2043	2432	2854	3310	3800	4323	5472
84	193.79	111.76	1094	1385	1543	1709	1885	2068	2461	2889	3350	3846	4376	5538
86	198.40	113.08	1107	1401	1561	1730	1907	2093	2491	2923	3390	3891	4428	5604
88	203.02	114.39	1120	1417	1579	1750	1929	2117	2519	2957	3429	3936	4479	5668
90	207.63	115.68	1132	1433	1597	1769	1951	2141	2548	2990	3468	3981	4529	5733
92	212.24	116.96	1145	1449	1614	1789	1972	2165	2576	3023	3506	4025	4579	5796
94	216.86	118.23	1157	1465	1632	1808	1994	2188	2604	3056	3544	4068	4629	5859
96	221.47	119.48	1169	1480	1649	1827	2015	2211	2631	3088	3582	4111	4678	5921
98	226.09	120.71	1182	1495	1666	1846	2035	2234	2659	3120	3619	4154	4726	5982
100	230.70	121.94	1194	1511	1683	1865	2056	2257	2686	3152	3655	4196	4774	6043
102	235.31	123.15	1205	1526	1700	1884	2077	2279	2712	3183	3692	4238	4822	6103
104	239.93	124.35	1217	1541	1716	1902	2097	2301	2739	3214	3728	4279	4869	6162
106	244.54	125.55	1229	1555	1733	1920	2117	2323	2765	3245	3763	4320	4916	6221
108	249.16	126.73	1240	1570	1749	1938	2137	2345	2791	3275	3799	4361	4962	6280
110	253.77	127.89	1252	1584	1765	1956	2157	2367	2817	3306	3834	4401	5007	6338
112	258.38	129.05	1263	1599	1781	1974	2176	2388	2842	3336	3869	4441	5053	6395
114	263.00	130.20	1274	1613	1797	1991	2195	2409	2867	3365	3903	4480	5098	6452
116	267.61	131.33	1286	1627	1813	2009	2215	2430	2892	3395	3937	4519	5142	6508
118	272.23	132.46	1297	1641	1828	2026	2234	2451	2917	3424	3971	4558	5186	6564
120	276.84	133.57	1308	1655	1844	2043	2252	2472	2942	3453	4004	4597	5230	6619
122	281.45	134.69	1318	1669	1859	2060	2271	2493	2966	3481	4038	4635	5273	6674
124	286.07	135.79	1329	1682	1874	2077	2290	2513	2991	3510	4070	4673	5317	6729
126	290.68	136.88	1340	1696	1889	2093	2308	2533	3015	3538	4103	4710	5359	6783
128	295.30	137.96	1350	1709	1904	2110	2326	2553	3038	3566	4136	4748	5402	6836
130	299.91	139.03	1361	1722	1919	2126	2344	2573	3062	3594	4168	4784	5444	6890
132	304.52	140.10	1371	1736	1934	2143	2362	2593	3086	3621	4200	4821	5485	6942
134	309.14	141.16	1382	1749	1948	2159	2380	2612	3109	3649	4231	4858	5527	6995
136	313.75	142.21	1392	1762	1963	2175	2398	2632	3132	3676	4263	4894	5568	7047

Notes:

(1) This table is computed from the formula $Q = 29.84cd^2\sqrt{p}$, with $c = 1.00$. The theoretical discharge of seawater, as from fireboat nozzles, can be found by subtracting 1 percent from the figures in Table 4.10.2.1, or from the formula $Q = 29.84cd^2\sqrt{p}$.
(2) Appropriate coefficient should be applied where it is read from hydrant outlet. Where more accurate results are required, a coefficient appropriate on the particular nozzle must be selected and applied to the figures of the table. The discharge from circular openings of sizes other than those in the table can readily be computed by applying the principle that quantity discharged under a given head varies as the square of the diameter of the opening.

N **Table 4.10.1(b) Theoretical Discharge Through Circular Orifices (Liters of Water per Minute)**

Pitot Pressure (kPa)	Pitot Pressure (bar)	Meters (m)	Orifice Size (mm)												
			44.5	50.8	57.2	60.3	63.5	66.7	69.9	76.2	82.6	88.9	95.3	101.6	114.3
5	0.05	0.51	295	384	487	541	600	663	728	865	1016	1177	1353	1537	1946
10	0.10	1.02	417	544	689	766	849	937	1029	1223	1437	1664	1913	2174	2751
15	0.15	1.53	511	666	844	938	1040	1148	1260	1498	1760	2039	2343	2663	3370
20	0.20	2.04	590	769	974	1083	1201	1325	1455	1729	2032	2354	2705	3075	3891
25	0.25	2.55	659	859	1090	1211	1343	1481	1627	1934	2272	2632	3024	3437	4350
30	0.30	3.06	722	941	1194	1326	1471	1623	1782	2118	2489	2883	3313	3765	4766
35	0.35	3.57	780	1017	1289	1433	1589	1753	1925	2288	2688	3114	3578	4067	5148
40	0.40	4.08	834	1087	1378	1532	1698	1874	2058	2446	2874	3329	3826	4348	5503
45	0.45	4.59	885	1153	1462	1624	1801	1988	2183	2594	3048	3531	4058	4612	5837
50	0.50	5.10	933	1215	1541	1712	1899	2095	2301	2734	3213	3722	4277	4861	6153
55	0.55	5.61	978	1275	1616	1796	1992	2197	2413	2868	3370	3904	4486	5099	6453
60	0.60	6.12	1022	1331	1688	1876	2080	2295	2521	2995	3520	4077	4685	5325	6740
65	0.65	6.63	1063	1386	1757	1952	2165	2389	2624	3118	3663	4244	4877	5543	7015
70	0.70	7.14	1103	1438	1823	2026	2247	2479	2723	3235	3802	4404	5061	5752	7280
75	0.75	7.65	1142	1488	1887	2097	2326	2566	2818	3349	3935	4558	5238	5954	7535
80	0.80	8.16	1180	1537	1949	2166	2402	2650	2911	3459	4064	4708	5410	6149	7782
85	0.85	8.67	1216	1585	2009	2233	2476	2732	3000	3565	4189	4853	5577	6338	8022
90	0.90	9.18	1251	1631	2067	2297	2548	2811	3087	3669	4311	4993	5738	6522	8254
95	0.95	9.69	1285	1675	2124	2360	2617	2888	3172	3769	4429	5130	5896	6701	8481
100	1.00	10.20	1319	1719	2179	2422	2685	2963	3254	3867	4544	5264	6049	6875	8701
105	1.05	10.71	1351	1761	2233	2481	2752	3036	3334	3963	4656	5394	6198	7045	8916
110	1.10	11.22	1383	1803	2285	2540	2817	3108	3413	4056	4766	5520	6344	7210	9126
115	1.15	11.73	1414	1843	2337	2597	2880	3177	3490	4147	4873	5645	6486	7372	9331
120	1.20	12.24	1445	1883	2387	2653	2942	3246	3565	4236	4978	5766	6626	7531	9531
125	1.25	12.75	1475	1922	2436	2707	3002	3313	3638	4324	5080	5885	6763	7686	9728
130	1.30	13.26	1504	1960	2484	2761	3062	3378	3710	4409	5181	6001	6897	7839	9921
140	1.40	14.28	1560	2034	2578	2865	3178	3506	3850	4576	5376	6228	7157	8134	10295
150	1.50	15.30	1615	2105	2669	2966	3289	3629	3985	4736	5565	6446	7408	8420	10656
160	1.60	16.32	1668	2174	2756	3063	3397	3748	4116	4892	5748	6658	7651	8696	11006
170	1.70	17.34	1720	2241	2841	3157	3501	3863	4243	5042	5925	6863	7887	8964	11345
180	1.80	18.36	1769	2306	2923	3249	3603	3975	4366	5188	6096	7062	8115	9224	11674
190	1.90	19.38	1818	2369	3004	3338	3702	4084	4485	5330	6263	7255	8338	9476	11993
200	2.00	20.40	1865	2431	3082	3425	3798	4190	4602	5469	6426	7444	8554	9722	12305
210	2.10	21.42	1911	2491	3158	3509	3892	4294	4716	5604	6585	7628	8765	9963	12609
220	2.20	22.44	1956	2549	3232	3592	3983	4395	4827	5736	6740	7807	8972	10197	12906
230	2.30	23.46	2000	2607	3305	3673	4073	4494	4935	5865	6891	7983	9173	10426	13196
240	2.40	24.48	2043	2663	3376	3752	4160	4590	5041	5991	7039	8154	9371	10650	13479
250	2.50	25.50	2085	2718	3445	3829	4246	4685	5145	6114	7185	8322	9564	10870	13757
260	2.60	26.52	2127	2771	3514	3905	4330	4778	5247	6235	7327	8487	9753	11085	14030
270	2.70	27.54	2167	2824	3581	3979	4413	4869	5347	6354	7466	8649	9939	11296	14297
285	2.85	29.07	2226	2902	3679	4088	4534	5002	5494	6528	7671	8886	10211	11606	14689
300	3.00	30.60	2284	2977	3774	4194	4651	5132	5636	6698	7870	9117	10477	11908	15070
315	3.15	32.13	2341	3050	3867	4298	4766	5259	5775	6863	8065	9342	10735	12202	15443
330	3.30	33.66	2396	3122	3958	4399	4878	5382	5911	7025	8255	9562	10988	12489	15806
345	3.45	35.19	2450	3192	4047	4498	4988	5503	6044	7183	8440	9777	11235	12769	16161
360	3.60	36.72	2502	3261	4134	4595	5095	5622	6174	7337	8622	9987	11477	13044	16509
375	3.75	38.25	2554	3328	4220	4689	5200	5738	6302	7489	8799	10193	11713	13313	16849
390	3.90	39.78	2605	3394	4303	4782	5303	5851	6426	7637	8974	10395	11945	13577	17183
405	4.05	41.31	2654	3459	4385	4873	5404	5963	6549	7782	9145	10593	12173	13835	17510
420	4.20	42.84	2703	3522	4466	4963	5504	6072	6669	7925	9312	10787	12396	14089	17832
435	4.35	44.37	2751	3585	4545	5051	5601	6180	6787	8065	9477	10978	12616	14339	18147
450	4.50	45.90	2798	3646	4622	5137	5697	6285	6903	8203	9639	11166	12831	14584	18458
465	4.65	47.43	2844	3706	4699	5222	5791	6389	7017	8339	9799	11350	13043	14825	18763
480	4.80	48.96	2889	3765	4774	5306	5884	6492	7129	8472	9955	11532	13252	15062	19063
495	4.95	50.49	2934	3824	4848	5388	5975	6592	7240	8604	10110	11711	13457	15296	19358
510	5.10	52.02	2978	3881	4921	5469	6065	6691	7349	8733	10262	11887	13660	15526	19650
525	5.25	53.55	3022	3938	4993	5549	6153	6789	7456	8861	10412	12060	13859	15752	19936
540	5.40	55.08	3065	3994	5064	5627	6240	6885	7562	8986	10559	12231	14056	15976	20219
555	5.55	56.61	3107	4049	5133	5705	6327	6980	7666	9110	10705	12400	14250	16196	20498
570	5.70	58.14	3149	4103	5202	5782	6411	7074	7769	9233	10849	12567	14441	16413	20773

(continues)

N **Table 4.10.1(b)** ***Continued***

Pitot Pressure (kPa)	Pitot Pressure (bar)	Meters (m)	Orifice Size (mm)												
			44.5	50.8	57.2	60.3	63.5	66.7	69.9	76.2	82.6	88.9	95.3	101.6	114.3
585	5.85	59.67	3190	4157	5270	5857	6495	7166	7871	9353	10990	12731	14630	16628	21045
600	6.00	61.20	3231	4210	5338	5932	6578	7258	7971	9472	11130	12893	14816	16840	21313
615	6.15	62.73	3271	4262	5404	6005	6660	7348	8070	9590	11269	13053	15000	17049	21578
630	6.30	64.26	3310	4314	5469	6078	6740	7437	8168	9706	11405	13211	15182	17256	21839
645	6.45	65.79	3349	4365	5534	6150	6820	7525	8264	9821	11540	13368	15362	17460	22098
660	6.60	67.32	3388	4415	5598	6221	6899	7612	8360	9935	11674	13522	15539	17662	22353
675	6.75	68.85	3426	4465	5661	6292	6977	7698	8454	10047	11806	13675	15715	17861	22606
690	6.90	70.38	3464	4515	5724	6361	7054	7783	8548	10158	11936	13826	15889	18059	22856
705	7.05	71.91	3502	4563	5786	6430	7130	7867	8640	10268	12065	13976	16060	18254	23103
720	7.20	73.44	3539	4612	5847	6498	7206	7950	8732	10376	12193	14124	16230	18447	23347
735	7.35	74.97	3576	4660	5908	6565	7281	8033	8822	10484	12319	14270	16398	18638	23589
750	7.50	76.50	3612	4707	5968	6632	7354	8114	8912	10590	12444	14415	16565	18827	23829
765	7.65	78.03	3648	4754	6027	6698	7428	8195	9000	10696	12568	14558	16730	19015	24066
780	7.80	79.56	3683	4800	6086	6763	7500	8275	9088	10800	12691	14700	16893	19200	24300
795	7.95	81.09	3719	4846	6144	6828	7572	8354	9175	10904	12812	14841	17055	19384	24533
810	8.10	82.62	3754	4892	6202	6892	7643	8433	9261	11006	12932	14980	17215	19566	24763
825	8.25	84.15	3788	4937	6259	6956	7713	8510	9347	11107	13052	15118	17373	19746	24992
840	8.40	85.68	3822	4981	6315	7019	7783	8587	9431	11208	13170	15255	17531	19925	25218
855	8.55	87.21	3856	5026	6372	7081	7852	8664	9515	11308	13287	15391	17687	20102	25442
870	8.70	88.74	3890	5069	6427	7143	7921	8739	9598	11406	13403	15525	17841	20278	25664
885	8.85	90.27	3923	5113	6482	7204	7989	8814	9681	11504	13518	15658	17994	20452	25884
900	9.00	91.80	3957	5156	6537	7265	8056	8889	9762	11601	13632	15791	18146	20624	26103
915	9.15	93.33	3989	5199	6591	7325	8123	8963	9843	11698	13745	15922	18297	20796	26319
930	9.30	94.86	4022	5241	6645	7385	8190	9036	9924	11793	13857	16052	18446	20965	26534
945	9.45	96.39	4054	5283	6699	7444	8255	9108	10003	11888	13969	16181	18594	21134	26747

Notes:

(1) This table is computed from the formula $Q_M = 0.0666cd^2\sqrt{p_M}$, with c = 1.00. The theoretical discharge of seawater, as from fireboat nozzles, can be found by subtracting 1 percent from the figures in Table 4.10.2.1, or from the formula $Q_M = 0.065cd^2\sqrt{p_M}$.
(2) Appropriate coefficient should be applied where it is read from the hydrant outlet. Where more accurate results are required, a coefficient appropriate on the particular nozzle must be selected and applied to the figures of the table. The discharge from circular openings of sizes other than those in the table can readily be computed by applying the principle that quantity discharged under a given head varies as the square of the diameter of the opening.

4.11.3 The back of the form should include a location sketch.

4.11.4 Results of the flow test should be indicated on a hydraulic graph, such as the one shown in Figure 4.11.4.

4.11.5 When the tests are complete, the forms should be filed for future reference by interested parties.

4.12 System Corrections.

4.12.1 It must be remembered that flow test results show the strength of the distribution system and do not necessarily indicate the degree of adequacy of the entire water works system.

4.12.2 Consider a system supplied by pumps at one location and having no elevated storage.

4.12.3 If the pressure at the pump station drops during the test, it is an indication that the distribution system is capable of delivering more than the pumps can deliver at their normal operating pressure.

4.12.4 It is necessary to use a value for the drop in pressure for the test that is equal to the actual drop obtained in the field during the test, minus the drop in discharge pressure at the pumping station.

4.12.5 If sufficient pumping capacity is available at the station and the discharge pressure could be maintained by operating additional pumps, the water system as a whole could deliver the computed quantity.

4.12.6 If, however, additional pumping units are not available, the distribution system would be capable of delivering the computed quantity, but the water system as a whole would be limited by the pumping capacity.

4.12.7 The portion of the pressure drop for which a correction can be made for tests on systems with storage is generally estimated upon the basis of a study of all the tests made and the pressure drops observed on the recording gauge at the station for each.

4.12.8 The corrections may vary from very substantial portions of the observed pressure drops for tests near the pumping station, to zero for tests remote from the station.

Table 4.10.2.1 Values of *h* to the 0.54 Power

h	$h^{0.54}$	*h*	$h^{0.54}$	*h*	$h^{0.54}$	*h*	$h^{0.54}$	*h*	$h^{0.54}$
1	1.00	36	6.93	71	9.99	106	12.41	141	14.47
2	1.45	37	7.03	72	10.07	107	12.47	142	14.53
3	1.81	38	7.13	73	10.14	108	12.53	143	14.58
4	2.11	39	7.23	74	10.22	109	12.60	144	14.64
5	2.39	40	7.33	75	10.29	110	12.66	145	14.69
6	2.63	41	7.43	76	10.37	111	12.72	146	14.75
7	2.86	42	7.53	77	10.44	112	12.78	147	14.80
8	3.07	43	7.62	78	10.51	113	12.84	148	14.86
9	3.28	44	7.72	79	10.59	114	12.90	149	14.91
10	3.47	45	7.81	80	10.66	115	12.96	150	14.97
11	3.65	46	7.91	81	10.73	116	13.03	151	15.02
12	3.83	47	8.00	82	10.80	117	13.09	152	15.07
13	4.00	48	8.09	83	10.87	118	13.15	153	15.13
14	4.16	49	8.18	84	10.94	119	13.21	154	15.18
15	4.32	50	8.27	85	11.01	120	13.27	155	15.23
16	4.48	51	8.36	86	11.08	121	13.33	156	15.29
17	4.62	52	8.44	87	11.15	122	13.39	157	15.34
18	4.76	53	8.53	88	11.22	123	13.44	158	15.39
19	4.90	54	8.62	89	11.29	124	13.50	159	15.44
20	5.04	55	8.71	90	11.36	125	13.56	160	15.50
21	5.18	56	8.79	91	11.43	126	13.62	161	15.55
22	5.31	57	8.88	92	11.49	127	13.68	162	15.60
23	5.44	58	8.96	93	11.56	128	13.74	163	15.65
24	5.56	59	9.04	94	11.63	129	13.80	164	15.70
25	5.69	60	9.12	95	11.69	130	13.85	165	15.76
26	5.81	61	9.21	96	11.76	131	13.91	166	15.81
27	5.93	62	9.29	97	11.83	132	13.97	167	15.86
28	6.05	63	9.37	98	11.89	133	14.02	168	15.91
29	6.16	64	9.45	99	11.96	134	14.08	169	15.96
30	6.28	65	9.53	100	12.02	135	14.14	170	16.01
31	6.39	66	9.61	101	12.09	136	14.19	171	16.06
32	6.50	67	9.69	102	12.15	137	14.25	172	16.11
33	6.61	68	9.76	103	12.22	138	14.31	173	16.16
34	6.71	69	9.84	104	12.28	139	14.36	174	16.21
35	6.82	70	9.92	105	12.34	140	14.42	175	16.26

Hydrant Flow Test Report

Location ____________________ Date __________

Test made by ____________________ Time __________

Representative of ____________________

Witness ____________________

State purpose of test ____________________

____

Consumption rate during test ____________________

If pumps affect test, indicate pumps operating ____________________

Flow hydrants: ______ A_1 A_2 A_3 A_4

Size nozzle ____________________

Pitot reading ____________________

Discharge coefficient ____________________ Total gpm

gpm ____________________

Static B __________ psi Residual B __________ psi

Projected results @20 psi Residual ____ gpm; or @ ____ psi Residual ____ gpm

Remarks ____________________

____

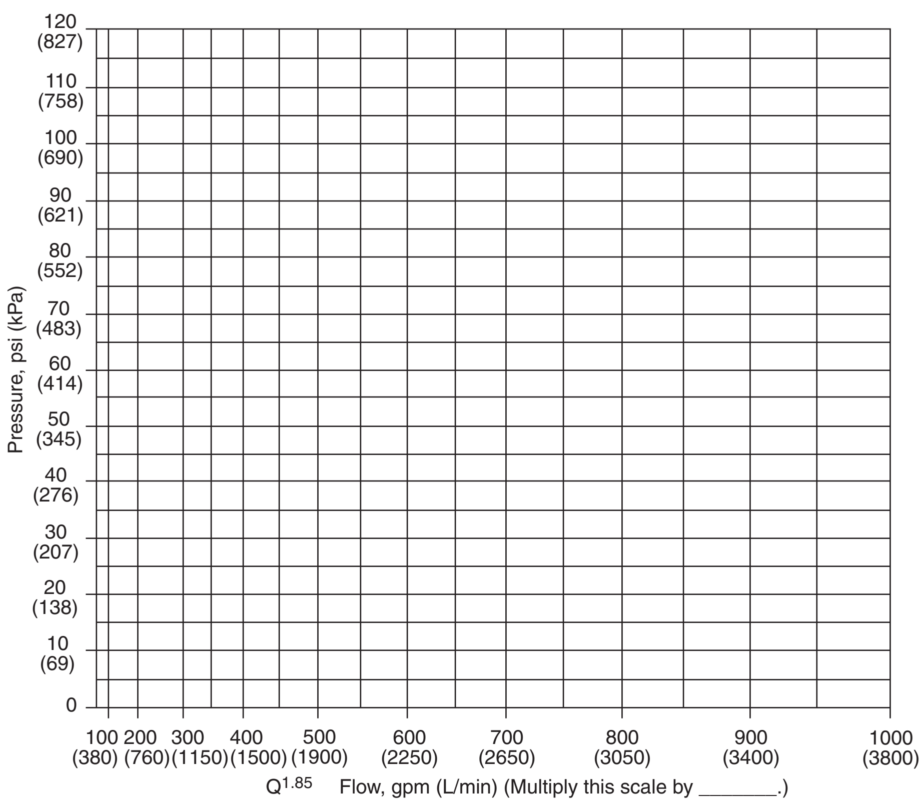
____

____

Location map: Show line sizes and distance to next cross-connected line. Show valves and hydrant branch size. Indicate north. Show flowing hydrants – Label A_1, A_2, A_3, A_4. Show location of static and residual – Label B.

Indicate B Hydrant ______ Sprinkler ______ Other (identify) ____________

FIGURE 4.11.2 Sample Report of a Hydrant Flow Test.



Δ **FIGURE 4.11.4 Sample Graph Sheet.**

4.13 Public Hydrant Testing and Flushing.

4.13.1* Public fire hydrants should be flow tested every 5 years to verify capacity and marking of the hydrant.

4.13.2 Public fire hydrants should be flushed at least annually to verify operation, address repairs, and verify reliability.

Chapter 5 Marking of Hydrants

5.1 Classification of Hydrants. Hydrants should be classified in accordance with their rated capacities [at 20 psi (1.4 bar) residual pressure or other designated value] as follows:

(1) Class AA — Rated capacity of 1500 gpm (5700 L/min) or greater
(2) Class A — Rated capacity of 1000–1499 gpm (3800–5699 L/min)
(3) Class B — Rated capacity of 500–999 gpm (1900–3799 L/min)
(4) Class C — Rated capacity of less than 500 gpm (1900 L/min)

5.2 Marking of Hydrants.

5.2.1 Public Hydrants.

5.2.1.1 All barrels are to be chrome yellow except in cases where another color has already been adopted.

5.2.1.2 The tops and nozzle caps should be painted with the following capacity-indicating color scheme to provide simplicity and consistency with colors used in signal work for safety, danger, and intermediate condition:

(1) Class AA — Light blue
(2) Class A — Green
(3) Class B — Orange
(4) Class C — Red

5.2.1.3 For rapid identification at night, it is recommended that the capacity colors be of a reflective-type paint.

5.2.1.4 Hydrants rated at less than 20 psi (1.4 bar) should have the rated pressure stenciled in black on the hydrant top.

5.2.1.5 In addition to the painted top and nozzle caps, it can be advantageous to stencil the rated capacity of high-volume hydrants on the top.

5.2.1.6 The classification and marking of hydrants provided for in this chapter anticipate determination based on individual flow test.

5.2.1.7 Where a group of hydrants can be used at the time of a fire, some special marking designating group-flow capacity may be desirable.

5.2.1.8 Marking on private hydrants within private enclosures is to be done at the owner's discretion.

5.2.1.9 When private hydrants are located on public streets, they should be painted red or another color to distinguish them from public hydrants.

5.2.2 Permanently Inoperative Hydrants. Fire hydrants that are permanently inoperative or unusable should be removed.

5.2.3 Temporarily Inoperative Hydrants. Fire hydrants that are temporarily inoperative or unusable should be wrapped or otherwise provided with temporary indication of their condition.

5.2.4 Flush Hydrants. Location markers for flush hydrants should carry the same background color as stated above for class indication, with such other data stenciled thereon as deemed necessary.

5.2.5 Private Hydrants.

5.2.5.1 Marking on private hydrants within private enclosures is to be at the owner's discretion.

5.2.5.2 When private hydrants are located on public streets, they should be painted red or some other color to distinguish them from public hydrants.

Annex A Explanatory Material

Annex A is not a part of the recommendations 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.3.2.1 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.3.2.2 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations 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.

A.4.13.1 When flow test data are needed, such data should not be more than 5 years old since conditions in the piping and system demands can change. It is not the intent of 4.13.1 to require routine 5-year testing of each hydrant if there is no immediate need for flow test data or if test data less than 5 years old are available from an adjacent hydrant on the same grid.

Annex B Informational References (Reserved)