NFPA® 291

Recommended Practice for Fire Flow Testing and Marking of Hydrants

2013 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

2013 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 Technical Correlating Committee on Automatic Sprinkler Systems. It was issued by the Standards Council on May 29, 2012, with an effective date of June 18, 2012, and supersedes all previous editions.

This edition of NFPA 291 was approved as an American National Standard on June 18, 2012.

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 utilizing 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 adds language recommending frequencies for flushing and flow testing of public hydrants in Section 4.13.

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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.

Contents

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Recommended Practice for

Fire Flow Testing and Marking of Hydrants

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Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

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.

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*, 1992.

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. Institute of Electrical and Electronics Engineers, 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,* 1992.

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 (2.8 bar).

4.1.2 Hydrants having a static pressure of less than 40 psi (2.8 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.

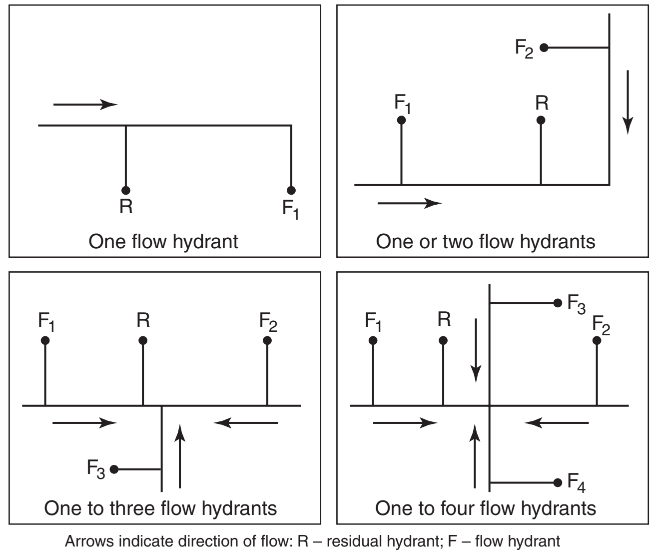

FIGURE 4.3.4 Suggested Test Layout for Hydrants.

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.

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 (0.0689 bar) graduations
(2) A number of pitot tubes
(3) Hydrant wrenches
(4) 50 or 60 psi (3.5 or 4.0 bar) bourdon pressure gauges with 1 psi (0.0689 bar) graduations, and scales with 1⁄16 in. (1.6 mm) graduations [one pitot tube, a 50 or 60 psi (3.5 or 4.0 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. (6.35 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. (6.4 cm) 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. (6.4 cm) outlets rather than pumper outlets.

4.6.2 In practically all cases, the 2½ in. (6.4 cm) 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 (2.0 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.

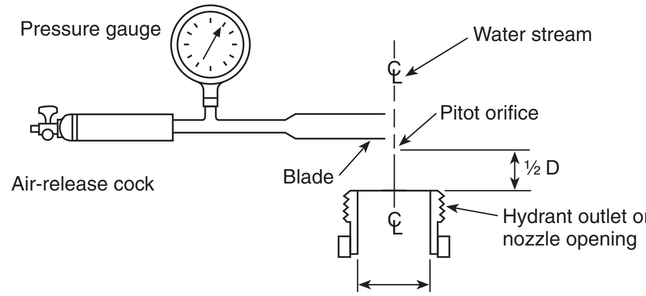

FIGURE 4.6.9 Pitot Tube Position.

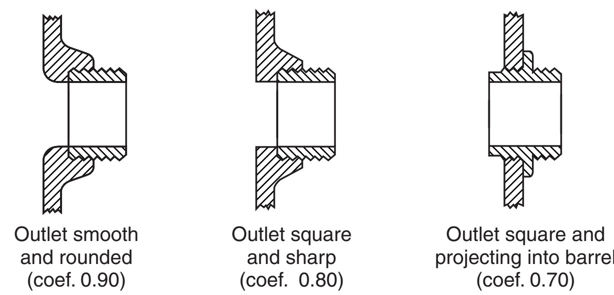

FIGURE 4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.

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 from these measurements is as follows:

$$Q = 29.84cd^2\sqrt{p} \qquad \textbf{(4.7.3)}$$

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

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 (0.3 bar and 0.7 bar).

4.8.2 For pumper outlets, the approximate discharge can be computed from Equation 4.7.3 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 Equation 4.7.3 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 (3.5 or 4.0 bar) gauge tapped into a hydrant cap can be used.

Table 4.8.2 Pumper Outlet Coefficients

Pitot Pressure (Velocity Head) psi	Pitot Pressure (Velocity Head) 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.

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 Equation 4.7.3.

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

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
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
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.

*This pressure corresponds to velocity head.

†1 psi = 2.307 ft of water. For pressure in bars, multiply by 0.07.

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

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)											
			51	57	60	64	67	70	76	83	89	95	101	114
6.89	0.70	3.72	455	568	629	716	785	857	1010	1204	1385	1578	1783	2272
13.8	1.41	5.26	644	804	891	1013	1111	1212	1429	1704	1960	2233	2524	3215
20.7	2.11	6.44	788	984	1091	1241	1360	1485	1750	2087	2400	2735	3091	3938
27.6	2.81	7.43	910	1137	1260	1433	1571	1714	2021	2410	2771	3158	3569	4547
34.5	3.52	8.31	1017	1271	1408	1602	1756	1917	2259	2695	3099	3530	3990	5084
41.4	4.22	9.10	1115	1392	1543	1755	1924	2100	2475	2952	3394	3867	4371	5569
48.3	4.92	9.83	1204	1504	1666	1896	2078	2268	2673	3189	3666	4177	4722	6015
55.2	5.63	10.51	1287	1608	1781	2027	2221	2425	2858	3409	3919	4466	5048	6431
62.0	6.33	11.15	1364	1704	1888	2148	2354	2570	3029	3613	4154	4733	5349	6815
68.9	7.03	11.75	1438	1796	1990	2264	2482	2709	3193	3808	4379	4989	5639	7184
75.8	7.73	12.33	1508	1884	2087	2375	2603	2841	3349	3995	4593	5233	5915	7536
82.7	8.44	12.87	1575	1968	2180	2481	2719	2968	3498	4172	4797	5466	6178	7871
89.6	9.14	13.40	1640	2048	2270	2582	2830	3089	3641	4343	4994	5690	6431	8193
96.5	9.84	13.91	1702	2126	2355	2680	2937	3206	3779	4507	5182	5905	6674	8503
103	10.55	14.39	1758	2196	2433	2769	3034	3312	3904	4656	5354	6100	6895	8784
110	11.25	14.87	1817	2269	2515	2861	3136	3423	4035	4812	5533	6304	7125	9078
117	11.95	15.33	1874	2341	2593	2951	3234	3530	4161	4963	5706	6502	7349	9362
124	12.66	15.77	1929	2410	2670	3038	3329	3634	4284	5109	5874	6693	7565	9638
131	13.36	16.20	1983	2477	2744	3122	3422	3735	4403	5251	6038	6880	7776	9906
138	14.06	16.62	2035	2542	2817	3205	3512	3834	4519	5390	6197	7061	7981	10168
152	15.47	17.43	2136	2668	2956	3363	3686	4023	4743	5657	6504	7410	8376	10671
165	16.88	18.21	2225	2779	3080	3504	3840	4192	4941	5893	6776	7721	8727	11118
179	18.28	18.95	2318	2895	3208	3650	4000	4366	5147	6138	7058	8042	9090	11580
193	19.69	19.67	2407	3006	3331	3790	4153	4534	5344	6374	7329	8350	9438	12024
207	21.10	20.36	2492	3113	3450	3925	4301	4695	5535	6601	7590	8648	9775	12453
221	22.50	21.03	2575	3217	3564	4055	4444	4851	5719	6821	7842	8935	10100	12867
234	23.91	21.67	2650	3310	3668	4173	4573	4992	5884	7018	8070	9195	10393	13240
248	25.31	22.30	2728	3408	3776	4296	4708	5139	6058	7225	8308	9466	10699	13630
262	26.72	22.91	2804	3502	3881	4416	4839	5282	6227	7426	8539	9729	10997	14010
276	28.13	23.50	2878	3595	3983	4532	4967	5422	6391	7622	8764	9986	11287	14379
290	29.53	24.09	2950	3685	4083	4646	5091	5557	6551	7813	8984	10236	11570	14740
303	30.94	24.65	3015	3767	4173	4748	5204	5681	6696	7986	9183	10463	11826	15066
317	32.35	25.21	3084	3853	4269	4857	5323	5810	6849	8169	9393	10702	12096	15410
331	33.75	25.75	3152	3937	4362	4963	5439	5937	6999	8347	9598	10935	12360	15747
345	35.16	26.28	3218	4019	4453	5067	5553	6061	7145	8522	9799	11164	12619	16077
358	36.57	26.80	3278	4094	4536	5161	5657	6175	7279	8681	9981	11373	12855	16377
372	37.97	27.31	3341	4173	4624	5261	5766	6294	7419	8849	10175	11593	13104	16694
386	39.38	27.80	3403	4251	4711	5360	5874	6412	7558	9014	10364	11809	13348	17005
400	40.78	28.31	3465	4328	4795	5456	5979	6527	7694	9176	10551	12021	13588	17311
414	42.19	28.79	3525	4403	4878	5551	6083	6640	7827	9335	10734	12230	13823	17611
427	43.60	29.26	3580	4471	4954	5637	6178	6743	7949	9481	10901	12420	14039	17885
441	45.00	29.73	3638	4544	5035	5729	6278	6853	8078	9635	11078	12622	14267	18176
455	46.41	30.20	3695	4616	5114	5819	6377	6961	8206	9787	11253	12821	14492	18462
469	47.82	30.65	3751	4686	5192	5908	6475	7067	8331	9936	11425	13017	14713	18744
483	49.22	31.10	3807	4756	5269	5995	6570	7172	8454	10083	11594	13210	14931	19022
496	50.63	31.54	3858	4819	5340	6075	6658	7268	8567	10218	11749	13386	15131	19276
510	52.03	31.97	3912	4887	5415	6161	6752	7370	8687	10361	11913	13574	15343	19547
524	53.44	32.71	3965	4953	5488	6245	6844	7470	8806	10503	12076	13759	15552	19813
538	54.85	32.82	4018	5019	5561	6327	6934	7569	8923	10642	12236	13942	15758	20076
552	56.25	33.25	4070	5084	5633	6409	7024	7667	9038	10780	12394	14122	15962	20335
565	57.66	33.66	4118	5143	5699	6484	7106	7757	9144	10906	12539	14287	16149	20573
579	59.07	34.06	4168	5207	5769	6564	7194	7853	9256	11040	12694	14463	16348	20827
593	60.47	34.47	4218	5269	5839	6643	7280	7947	9368	11173	12846	14637	16544	21077
607	61.88	34.87	4268	5331	5907	6721	7366	8040	9478	11304	12997	14809	16738	21324
620	63.29	35.26	4313	5388	5970	6793	7444	8126	9578	11424	13136	14966	16917	21552
634	64.69	35.65	4362	5448	6037	6869	7528	8217	9686	11552	13283	15134	17107	21794
648	66.10	36.04	4410	5508	6103	6944	7610	8307	9792	11679	13429	15301	17294	22033

Table 4.10.1(b) *Continued*

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)											
			51	57	60	64	67	70	76	83	89	95	101	114
662	67.50	36.42	4457	5567	6169	7019	7692	8397	9898	11805	13573	15465	17480	22270
676	68.91	36.79	4504	5626	6234	7093	7773	8485	10002	11929	13716	15628	17664	22504
689	70.32	37.17	4547	5680	6293	7161	7848	8566	10097	12043	13847	15777	17833	22719
703	71.72	37.54	4593	5737	6357	7233	7927	8653	10200	12165	13987	15937	18013	22949
717	73.13	37.90	4638	5794	6420	7305	8005	8738	10301	12285	14126	16095	18192	23176
731	74.54	38.27	4684	5850	6482	7376	8083	8823	10401	12405	14263	16251	18369	23401
745	75.94	38.63	4728	5906	6544	7446	8160	8907	10500	12523	14399	16406	18544	23624
758	77.35	38.98	4769	5957	6601	7510	8231	8985	10591	12632	14524	16548	18705	23830
772	78.76	39.33	4813	6012	6662	7580	8307	9067	10688	12748	14658	16701	18877	24049
786	80.16	39.68	4857	6066	6722	7648	8382	9149	10785	12863	14790	16851	19047	24266
800	81.57	40.03	4900	6120	6781	7716	8456	9230	10880	12977	14921	17001	19216	24481
813	82.97	40.37	4939	6170	6836	7778	8525	9305	10968	13082	15042	17138	19371	24679
827	84.38	40.71	4982	6223	6895	7845	8598	9385	11063	13194	15171	17285	19538	24891
841	85.79	41.05	5024	6275	6953	7911	8670	9464	11156	13305	15299	17431	19702	25100
855	87.19	41.39	5065	6327	7011	7977	8742	9542	11248	13416	15425	17575	19866	25309
869	88.60	41.72	5107	6379	7068	8042	8813	9620	11340	13525	15551	17719	20028	25515
882	90.01	42.05	5145	6426	7121	8102	8879	9692	11424	13626	15667	17851	20177	25705
896	91.41	42.38	5185	6477	7177	8166	8949	9768	11515	13734	15791	17992	20336	25908
910	92.82	42.70	5226	6527	7233	8229	9019	9844	11604	13840	15914	18132	20495	26110
924	94.23	43.03	5266	6577	7288	8292	9088	9920	11693	13947	16036	18271	20652	26310
938	95.63	43.35	5305	6627	7343	8355	9156	9995	11782	14052	16157	18409	20807	26509

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 $Q_m = 0.065cd^2m\sqrt{P_m}$.
(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.
*This pressure corresponds to velocity head.
†1 kPa = 0.102 m of water. For pressure in bars, multiply by 0.01.

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:

$$Q_R = Q_F \times \frac{h_r^{0.54}}{h_f^{0.54}} \qquad \textbf{(4.10.1.2)}$$

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.

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

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.

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.

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.

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.

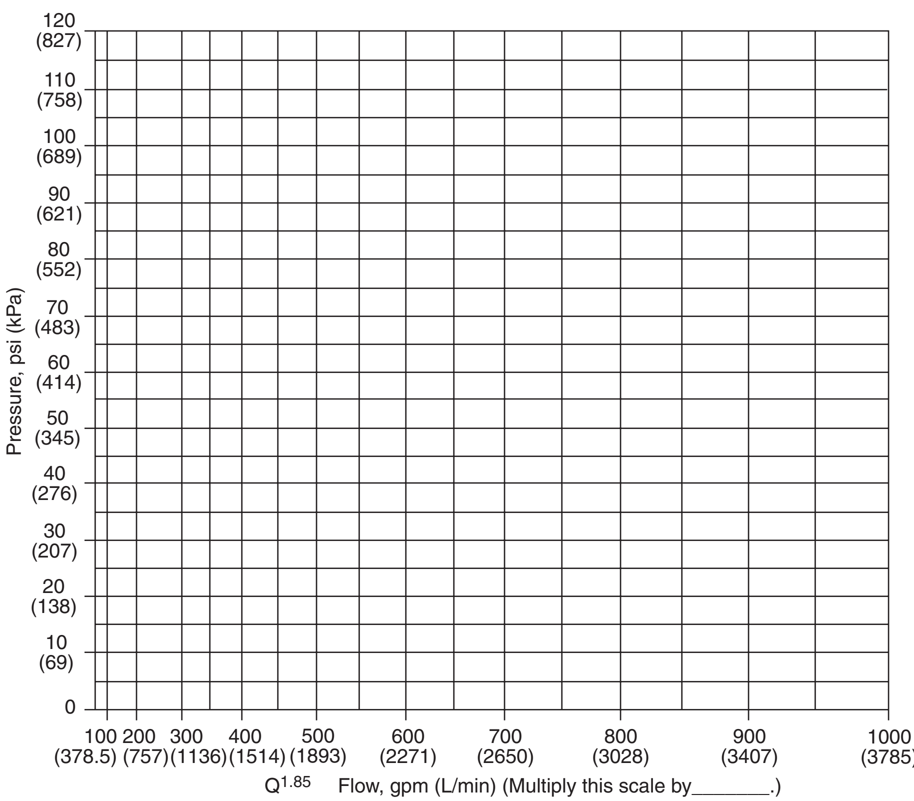

FIGURE 4.11.4 Sample Graph Sheet.

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 (5680 L/min) or greater
(2) Class A — Rated capacity of 1000–1499 gpm (3785–5675 L/min)
(3) Class B — Rated capacity of 500–999 gpm (1900–3780 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)