

NFPA[®] 291

Recommended Practice for Fire Flow Testing and Marking of Hydrants

2016 Edition



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NFPA®291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

2016 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 26, 2015, with an effective date of June 15, 2015, and supersedes all previous editions.

This edition of NFPA 291 was approved as an American National Standard on June 15, 2015.

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

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

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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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NFPA 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

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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.

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.

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.

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.

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*, 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 (2.7 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.

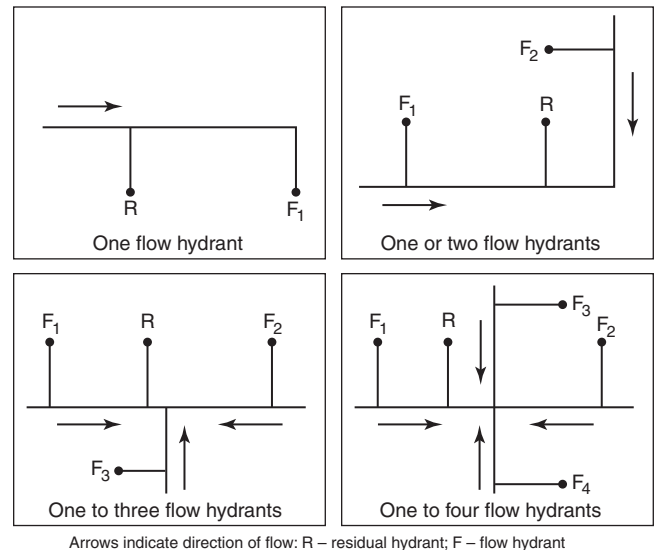


FIGURE 4.3.4 Suggested Test Layout for Hydrants.

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.

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 $\frac{1}{16}$ 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 $\frac{1}{4}$ 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 $2\frac{1}{2}$ 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 $2\frac{1}{2}$ in. (65 mm) outlets rather than pumper outlets.

4.6.2 In practically all cases, the $2\frac{1}{2}$ 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.

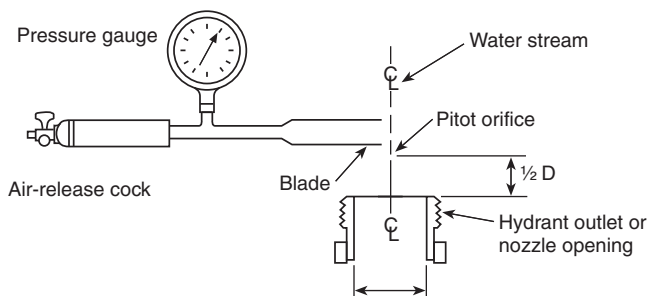


FIGURE 4.6.9 Pitot Tube Position.

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.

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.

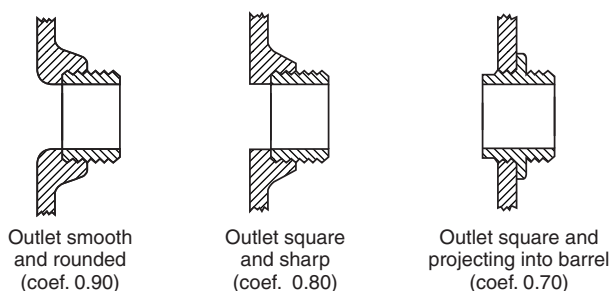


FIGURE 4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.

4.7.3 The formula used to compute the discharge, Q , in gpm from these measurements is as follows:

$$Q = 29.84cd^2\sqrt{p} \quad [4.7.3]$$

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 (0.34 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 (3.4 or 4.1 bar) gauge tapped into a hydrant cap can be used.

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.

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.

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.

Table 4.8.2 Pumper Outlet Coefficients

Pitot Pressure (Velocity Head)		Coefficient
psi	bar	
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

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)

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.

*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)											
			50	57	60	65	67	70	80	83	90	95	100	114
6.89	0.70	3.72	450	572	636	708	780	856	1015	1192	1385	1590	1806	2286
13.79	1.41	5.26	640	810	901	999	1102	1208	1438	1688	1957	2245	2555	3237
							13601							
20.68	2.11	6.44	784	992	1105	1223	348	1480	1760	2067	2396	2752	3131	3963
27.58	2.81	7.43	905	1143	1276	1412	1556	1741	2033	2385	2767	3176	3615	4577
34.47	3.52	8.31	1011	1279	1423	1579	1741	1912	2275	2669	3093	3551	4043	5114
41.37	4.22	9.10	1105	1401	1560	1730	1908	2093	2491	2922	3388	3891	4425	5602
48.26	4.92	9.83	1196	1514	1685	1866	2059	2260	2691	3157	3660	4202	4781	6053
55.16	5.63	10.51	1279	1616	1802	1999	2203	2415	2877	3373	3914	4493	5110	6469
62.05	6.33	11.15	1355	1715	1912	2120	2336	2563	3051	3581	4153	4766	5421	6868
68.95	7.03	11.75	1427	1809	2014	2233	2461	2703	3214	3774	4376	5023	5716	7234
75.84	7.74	12.33	1499	1896	2112	2343	2582	2831	3373	3956	4588	5269	5992	7586
82.74	8.44	12.87	1563	1980	2207	2445	2695	2960	3520	4134	4792	5504	6261	7923
89.63	9.14	13.40	1628	2063	2298	2544	2805	3081	3664	4300	4989	5727	6515	8248
96.53	9.85	13.91	1692	2139	2385	2642	2911	3195	3804	4463	5178	5943	6761	8559
103.42	10.55	14.39	1749	2214	2468	2733	3013	3308	3937	4622	5360	6151	6999	8858
110.32	11.25	14.87	1806	2286	2548	2824	3112	3418	4066	4773	5534	6356	7230	9149
117.21	11.95	15.33	1862	2358	2627	2911	3210	3520	4190	4921	5705	6549	7453	9429
124.11	12.66	15.77	1915	2426	2703	2994	3301	3623	4312	5061	5871	6738	7669	9706
131.00	13.36	16.20	1968	2491	2778	3078	3392	3725	4433	5201	6030	6924	7877	9971
137.90	14.06	16.62	2021	2559	2850	3157	3483	3819	4546	5337	6189	7105	8082	10228
151.68	15.47	17.43	2120	2684	2987	3312	3649	4005	4770	5595	6492	7450	8476	10728
165.47	16.88	18.21	2214	2801	3123	3460	3812	4187	4982	5845	6780	7783	8854	11205
179.26	18.28	18.95	2305	2915	3248	3600	3967	4357	5182	6083	7056	8101	9214	11663
193.05	19.69	19.67	2392	3025	3373	3736	4119	4520	5379	6314	7321	8404	9562	12102
206.84	21.10	20.36	2476	3131	3490	3869	4262	4679	5568	6534	7578	8699	9899	12530
220.63	22.50	21.03	2555	3237	3604	3994	4402	4834	5750	6749	7828	8987	10224	12939
234.42	23.91	21.67	2635	3335	3713	4115	4539	4982	5928	6958	8067	9263	10539	13336
248.21	25.31	22.30	2710	3430	3823	4236	4671	5125	6098	7158	8301	9532	10845	13726
262.00	26.72	22.91	2786	3524	3929	4353	4800	5266	6269	7355	8529	9793	11140	14101
275.79	28.13	23.50	2858	3615	4031	4467	4921	5402	6431	7544	8752	10046	11432	14468
289.58	29.53	24.09	2930	3706	4130	4577	5046	5534	6587	7734	8968	10293	11712	14824
303.37	30.94	24.65	2998	3793	4225	4683	5163	5667	6742	7915	9180	10535	11988	15172
317.16	32.35	25.21	3066	3880	4323	4789	5281	5795	6893	8093	9384	10773	12257	15513
330.95	33.75	25.75	3131	3963	4414	4891	5394	5917	7045	8267	9588	11004	12522	15846
344.74	35.16	26.28	3195	4043	4505	4993	5504	6042	7188	8438	9785	11231	12780	16175
358.53	36.56	26.80	3259	4122	4595	5091	5614	6159	7332	8604	9978	11455	13033	16493
372.32	37.97	27.31	3320	4202	4683	5186	5720	6276	7472	8767	10168	11674	13279	16807
386.11	39.38	27.80	3380	4278	4770	5284	5826	6394	7609	8930	10353	11886	13525	17118
399.90	40.79	28.31	3441	4353	4853	5375	5928	6507	7741	9085	10539	12098	13764	17420
413.69	42.19	28.79	3502	4429	4936	5470	6030	6617	7874	9240	10717	12303	13998	17720
427.47	43.60	29.26	3558	4501	5016	5561	6129	6727	8006	9395	10894	12507	14229	18011
441.26	45.00	29.73	3615	4577	5099	5648	6227	6833	8131	9543	11069	12708	14460	18299
455.05	46.41	30.20	3672	4645	5175	5735	6322	6939	8260	9694	11243	12904	14684	18583
468.84	47.82	30.65	3725	4717	5254	5822	6420	7045	8385	9838	11409	13098	14903	18863
482.63	49.22	31.10	3782	4785	5330	5905	6511	7147	8506	9982	11576	13291	15123	19139
496.42	50.63	31.54	3835	4853	5406	5992	6606	7249	8627	10122	11742	13480	15335	19408
510.21	52.04	31.97	3888	4921	5481	6072	6696	7347	8744	10262	11901	13665	15547	19667
524.00	53.44	32.40	3941	4985	5553	6155	6787	7446	8862	10402	12064	13847	15755	19942
537.79	54.85	32.82	3990	5050	5629	6235	6874	7544	8979	10539	12219	14029	15963	20203
551.58	56.25	33.25	4043	5114	5697	6314	6961	7639	9093	10671	12375	14207	16164	20460
565.37	57.66	33.66	4092	5178	5769	6394	7048	7734	9206	10804	12530	14385	16364	20714
579.16	59.07	34.06	4141	5243	5841	6469	7136	7828	9316	10936	12681	14559	16565	20964
592.95	60.47	34.47	4190	5303	5909	6549	7219	7923	9429	11065	12833	14729	16762	21213
606.74	61.88	34.87	4240	5364	5977	6624	7302	8014	9535	11193	12980	14899	16955	21456

(continues)

Table 4.10.1(b) *Continued*

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)											
			50	57	60	65	67	70	80	83	90	95	100	114
620.53	63.29	35.26	4285	5424	6045	6696	7385	8105	9645	11318	13128	15070	17144	21702
634.32	64.69	35.65	4334	5485	6110	6772	7465	8195	9751	11443	13272	15236	17333	21940
648.11	66.10	36.04	4380	5546	6178	6844	7548	8282	9857	11568	13416	15399	17523	22179
661.90	67.50	36.42	4425	5602	6242	6916	7628	8370	9959	11689	13559	15562	17708	22413
675.69	68.91	36.79	4474	5659	6306	6988	7703	8457	10065	11810	13699	15725	17890	22644
689.48	70.32	37.17	4520	5720	6371	7060	7783	8544	10168	11932	13836	15884	18072	22875
703.27	71.72	37.54	4561	5777	6435	7132	7862	8627	10266	12049	13976	16043	18253	23102
717.05	73.13	37.90	4607	5833	6496	7200	7938	8710	10368	12166	14112	16198	18431	23326
730.84	74.54	38.27	4652	5886	6560	7268	8014	8794	10467	12284	14245	16353	18609	23549
744.63	75.94	38.63	4694	5943	6621	7336	8089	8877	10565	12397	14381	16508	18783	23772
758.42	77.35	38.98	4739	5996	6681	7404	8165	8960	10664	12515	14513	16660	18954	23992
772.21	78.75	39.33	4781	6053	6742	7472	8237	9040	10758	12628	14646	16811	19128	24208
786.00	80.16	39.68	4823	6106	6802	7537	8309	9119	10853	12738	14747	16959	19298	24423
799.79	81.57	40.03	4868	6159	6863	7605	8385	9199	10947	12851	14903	17106	19465	24635
813.58	82.98	40.37	4910	6212	6920	7669	8457	9278	11042	12961	15032	17254	19631	24847
827.37	84.38	40.71	4951	6265	6980	7734	8525	9358	11137	13071	15157	17402	19798	25056
841.16	85.79	41.05	4989	6318	7037	7798	8597	9437	11228	13177	15285	17545	19960	25264
854.95	87.19	41.39	5031	6367	7094	7862	8669	9513	11322	13287	15407	17689	20127	25472
868.74	88.60	41.72	5072	6320	7151	7923	8737	9588	11413	13393	15532	17829	20286	25676
882.53	90.01	42.05	5110	6469	7207	7987	8805	9664	11500	13499	15656	17973	20449	25877
896.32	91.41	42.38	5152	6518	7264	8048	8873	9740	11591	13605	15778	18109	20608	26081
910.11	92.82	42.70	5190	6571	7321	8112	8941	9816	11682	13707	15899	18249	20763	26278
923.90	94.23	43.03	5231	6621	7374	8173	9009	9887	11769	13813	16016	18390	20992	26479
937.69	95.63	43.35	5269	6670	7431	8233	9077	9963	11856	13915	16137	18526	21077	26676

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.

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

4.12.4 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.

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

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 _____
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.

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.

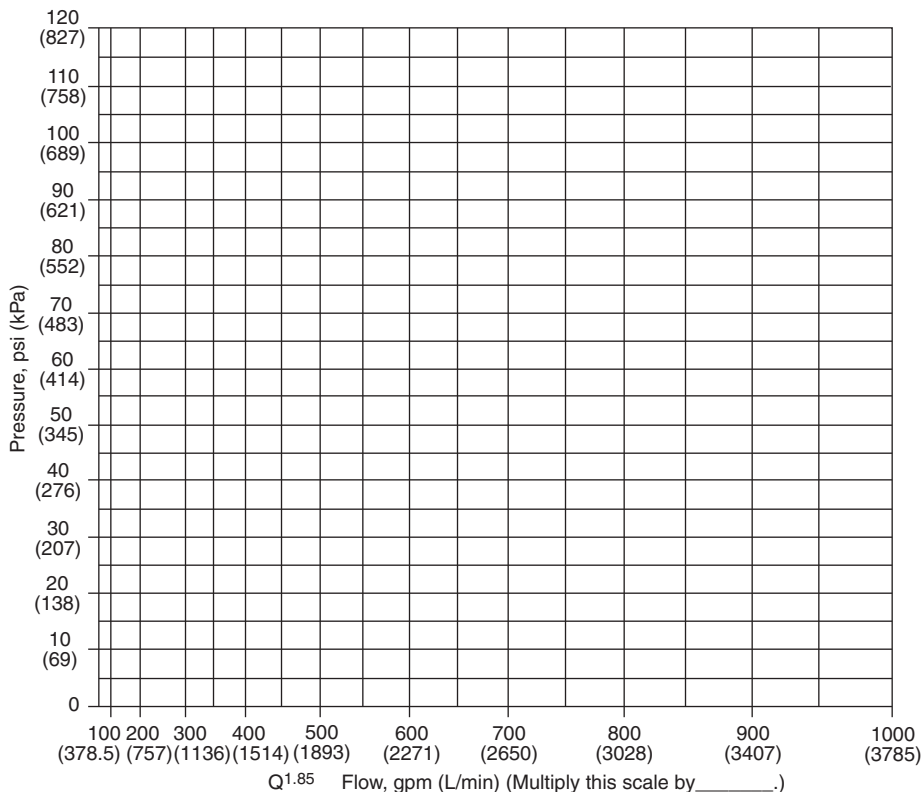


FIGURE 4.11.4 Sample Graph Sheet.

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)

Index

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