NFPA 291

Recommended Practice for

Fire Flow Testing and Marking of Hydrants

2007 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 July 28, 2006, with an effective date of August 17, 2006, and supersedes all previous editions.

This edition of NFPA 291 was approved as an American National Standard on August 17, 2006.

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 represents a reconfirmation of the 2002 edition, as there are no technical changes.

Technical Correlating Committee on Automatic Sprinkler Systems (AUT-AAC)

John G. O'Neill, *Chair*
The Protection Engineering Group, PC, VA [SE]

Christian Dubay, *Nonvoting Secretary*
National Fire Protection Association, MA

Jose R. Baz, International Engineered Systems Limited, Inc., FL [M]
Rep. NFPA Latin American Section

Kerry M. Bell, Underwriters Laboratories Inc., IL [RT]

Russell P. Fleming, National Fire Sprinkler Association, NY [M]

Scott T. Franson, The Viking Corporation, MI [M]

Raymond A. Grill, The RJA Group, Inc., NC [SE]

James B. Harmes, Grand Blanc Fire Department, MI [E]
Rep. International Association of Fire Chiefs

Luke Hilton, Liberty Mutual Property, FL [I]

Alex Hoffman, Viking Fire Protection Inc., Canada [IM]
Rep. Canadian Automatic Sprinkler Association

Roland J. Huggins, American Fire Sprinkler Association, Inc., TX [IM]

Sultan M. Javeri, SC Engineering, France [IM]

Andrew Kim, National Research Council of Canada, Canada [RT]

Joe W. Noble, Clark County Fire Department, NV [E]
Rep. International Fire Marshals Association

Eric Packard, Local 669 JATC Education Fund, MD [L]
Rep. United Association of Journeymen & Apprentices of the Plumbing & Pipe Fitting Industry of the U.S. & Canada

Chester W. Schirmer, Schirmer Engineering Corporation, NC [I]

Robert D. Spaulding, FM Global, MA [I]
Rep. FM Global

Lynn K. Underwood, Axis U.S. Property, IL [I]

Alternates

Donald "Don" D. Becker, RJC & Associates, Inc., MO [IM]
(Alt. to R. J. Huggins)

George Capko, Jr., FM Global, MA [I]
(Alt. to R. D. Spaulding)

Randall S. Chaney, Liberty Mutual Property, CA [I]
(Alt. to L. Hilton)

Kenneth E. Isman, National Fire Sprinkler Association, NY [M]
(Alt. to R. P. Fleming)

George E. Laverick, Underwriters Laboratories Inc., IL [RT]
(Alt. to K. M. Bell)

Donald C. Moeller, The RJA Group, Inc., CA [SE]
(Alt. to R. A. Grill)

Garner A. Palenske, Schirmer Engineering Corporation, CA [I]
(Alt. to C. W. Schirmer)

Donato A. Pirro, Electro Sistemas De Panama, S.A., Panama [M]
(Alt. to J. R. Baz)

J. Michael Thompson, The Protection Engineering Group, PC, VA [SE]
(Alt. to J. G. O'Neill)

Nonvoting

Antonio C. M. Braga, FM Global, CA [I]
Rep. TC on Hanging and Bracing of Water-Based Systems

Edward K. Budnick, Hughes Associates, Inc., MD [SE]
Rep. TC on Sprinkler System Discharge Criteria

Robert M. Gagnon, Gagnon Engineering, MD [SE]
Rep. TC on Foam-Water Sprinklers

William E. Koffel, Koffel Associates, Inc., MD [SE]

Rep. Safety to Life Correlating Committee

Kenneth W. Linder, GE Global Asset Protection Services, CT [I]
Rep. TC on Sprinkler System Installation Criteria

Daniel Madrzykowski, U.S. National Institute of Standards and Technology, MD [RT]
Rep. TC on Residential Sprinkler Systems

J. William Sheppard, General Motors Corporation, MI [U]
Rep. TC on Private Water Supply Piping Systems

John J. Walsh, UA Joint Apprenticeship Committee, MD [SE]
(Member Emeritus)

Christian Dubay, NFPA Staff Liaison

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

Committee Scope: This Committee shall have overall responsibility for documents that pertain to the criteria for the design and installation of automatic, open and foam-water sprinkler systems including the character and adequacy of water supplies, and the selection of sprinklers, piping, valves, and all materials and accessories. This Committee does not cover the installation of tanks and towers, nor the installation, maintenance, and use of central station, proprietary, auxiliary, and local signaling systems for watchmen, fire alarm, supervisory service, nor the design of fire department hose connections.

Technical Committee on Private Water Supply Piping Systems (AUT-PRI)

J. William Sheppard, *Chair*
General Motors Corporation, MI [U]
Rep. NFPA Industrial Fire Protection Section

Christian Dubay, *Nonvoting Secretary*
National Fire Protection Association, MA

James B. Biggins, Marsh Risk Consulting, IL [I]

Richard W. Bonds, Ductile Iron Pipe Research Association, AL [M]

Phillip A. Brown, American Fire Sprinkler Association, Inc., TX [IM]

Richard R. Brown, Brown Sprinkler Corporation, KY [IM]
Rep. National Fire Sprinkler Association

Stephen A. Clark, Jr., Allianz Risk Consultants, GA [I]

Brandon W. Frakes, GE Insurance Solutions, NC [I]

Robert M. Gagnon, Gagnon Engineering, MD [SE]

David M. Gough, Global Risk Consultants Corporation, CT [SE]

Luke Hilton, Liberty Mutual Property, FL [I]
Rep. Property Casualty Insurers Association of America

Gerald Kelliher, Westinghouse Savannah River Company, SC [U]

Kevin J. Kelly, National Fire Sprinkler Association, NY [M]

Marshall A. Klein, Marshall A. Klein & Associates, Inc., MD [SE]

Alan R. Laguna, Merit Sprinkler Company, Inc., LA [IM]

John Lake, Marion County Fire Rescue, FL [E]

George E. Laverick, Underwriters Laboratories Inc., IL [RT]

James M. Maddry, James M. Maddry, P.E., GA [SE]

Kevin D. Maughan, Tyco Fire & Building Products, RI [M]

David S. Mowrer, HSB Professional Loss Control, TN [I]

Robert A. Panero, Pacific Gas and Electric Company, CA [U]
Rep. Edison Electric Institute

Sam (Sat) Salwan, Environmental Systems Design, Inc., IL [SE]

James R. Schifiliti, Fire Safety Consultants, Inc., IL [IM]
Rep. Illinois Fire Prevention Association

James W. Simms, The RJA Group, Inc., CA [SE]

Alternates

Mark A. Bowman, GE Insurance Solutions, OH [I]
(Alt. to B. W. Frakes)

James K. Clancy, The RJA Group, Inc., CA [SE]
(Alt. to J. W. Simms)

W. Clark Gey, Wayne Automatic Fire Sprinklers, Inc., FL [IM]
(Alt. to R. R. Brown)

David M. Hammerman, Marshall A. Klein & Associates, Inc., MD [SE]
(Alt. to M. A. Klein)

Charles F. Hill, Ryan Fire Protection, Inc., IN [M]
(Alt. to K. J. Kelly)

Blake M. Shugarman, Underwriters Laboratories Inc., IL [RT]
(Alt. to G. E. Laverick)

Lawrence Thibodeau, Hampshire Fire Protection Company Inc., NH [IM]
(Alt. to P. A. Brown)

Nonvoting

Geoffrey N. Perkins, Bassett Consulting Engineers, Australia [SE]

Christian Dubay, NFPA Staff Liaison

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

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

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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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.

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 should 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.

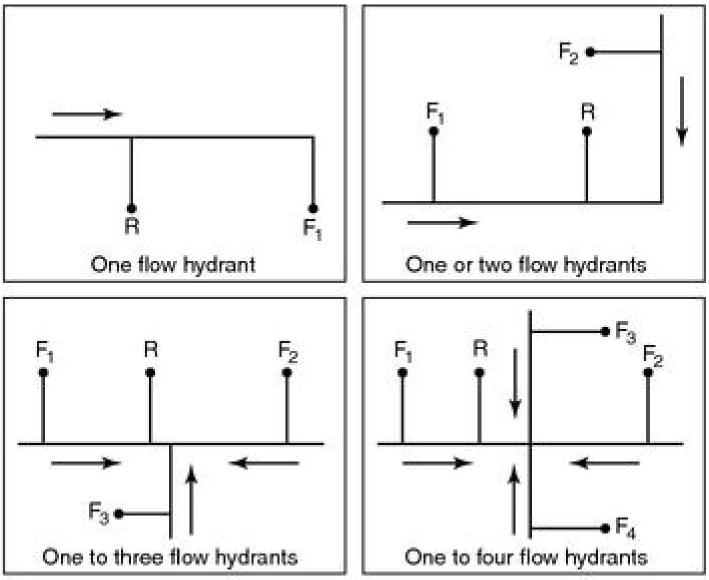
4.3 Layout of Test.

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.



Arrows indicate direction of flow; R – residual hydrant; F – flow hydrant

FIGURE 4.3.4 Suggested Test Layout for Hydrants.

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 (0.0689 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 $\frac{1}{16}$ 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 a short length of ¼ in. (6.35 mm) brass pipe is fitted; this pipe is 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.)*

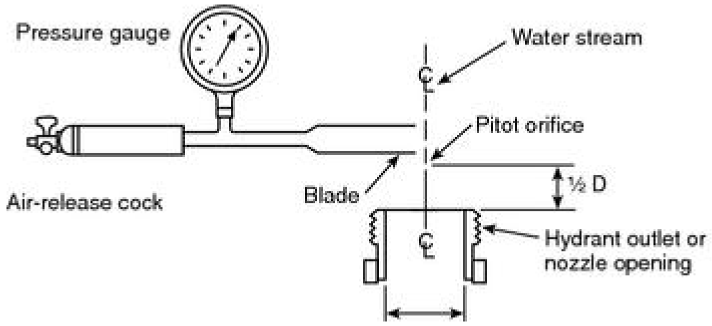


FIGURE 4.6.9 Pitot Tube Position.

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.

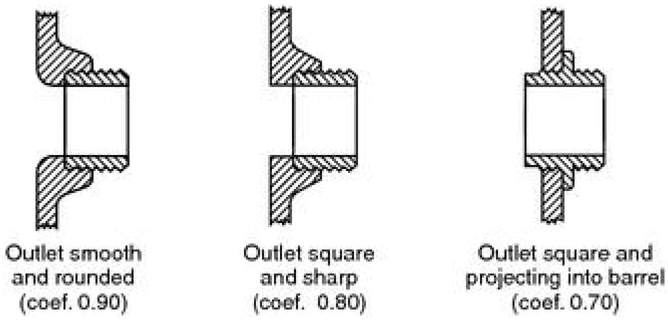


FIGURE 4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.

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).

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

4.8.3 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.

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. Gall

Pitot Pressure* (psi)	Feet†	Velocity Discharge (ft/sec)	Orifice Size (in.)						
			2	2.25	2.375	2.5	2.625	2.75	3
1	2.31	12.20	119	151	168	187	206	226	269
2	4.61	17.25	169	214	238	264	291	319	380
3	6.92	21.13	207	262	292	323	356	391	465
4	9.23	24.39	239	302	337	373	411	451	537
5	11.54	27.26	267	338	376	417	460	505	601
6	13.84	29.87	292	370	412	457	504	553	658
7	16.15	32.26	316	400	445	493	544	597	711
8	18.46	34.49	338	427	476	528	582	638	760
9	20.76	36.58	358	453	505	560	617	677	806
10	23.07	38.56	377	478	532	590	650	714	849
11	25.38	40.45	396	501	558	619	682	748	891
12	27.68	42.24	413	523	583	646	712	782	930
13	29.99	43.97	430	545	607	672	741	814	968
14	32.30	45.63	447	565	630	698	769	844	100
15	34.61	47.22	462	585	652	722	796	874	104
16	36.91	48.78	477	604	673	746	822	903	107
17	39.22	50.28	492	623	694	769	848	930	110
18	41.53	51.73	506	641	714	791	872	957	113
19	43.83	53.15	520	658	734	813	896	984	117
20	46.14	54.54	534	676	753	834	920	1009	120
22	50.75	57.19	560	709	789	875	964	1058	126
24	55.37	59.74	585	740	825	914	1007	1106	131
26	59.98	62.18	609	770	858	951	1048	1151	136
28	64.60	64.52	632	799	891	987	1088	1194	142
30	69.21	66.79	654	827	922	1022	1126	1236	147

Table 4.10.1(a) Theoretical Discharge Through Circular Orifices (U.S. Gall

Pitot Pressure* (psi)	Feet†	Velocity Discharge (ft/sec)	Orifice Size (in.)						
			2	2.25	2.375	2.5	2.625	2.75	3
32	73.82	68.98	675	855	952	1055	1163	1277	151
34	78.44	71.10	696	881	981	1087	1199	1316	156
36	83.05	73.16	716	906	1010	1119	1234	1354	161
38	87.67	75.17	736	931	1038	1150	1268	1391	165
40	92.28	77.11	755	955	1065	1180	1300	1427	169
42	96.89	79.03	774	979	1091	1209	1333	1462	174
44	101.51	80.88	792	1002	1116	1237	1364	1497	178
46	106.12	82.70	810	1025	1142	1265	1395	1531	182
48	110.74	84.48	827	1047	1166	1292	1425	1563	186
50	115.35	86.22	844	1068	1190	1319	1454	1596	189
52	119.96	87.93	861	1089	1214	1345	1483	1627	193
54	124.58	89.61	877	1110	1237	1370	1511	1658	197
56	129.19	91.20	893	1130	1260	1396	1539	1689	201
58	133.81	92.87	909	1150	1282	1420	1566	1719	204
60	138.42	94.45	925	1170	1304	1445	1593	1748	208
62	143.03	96.01	940	1189	1325	1469	1619	1777	211
64	147.65	97.55	955	1209	1347	1492	1645	1805	214
66	152.26	99.07	970	1227	1367	1515	1670	1833	218
68	156.88	100.55	984	1246	1388	1538	1696	1861	221
70	161.49	102.03	999	1264	1408	1560	1720	1888	224
72	166.10	103.47	1013	1282	1428	1583	1745	1915	227
74	170.72	104.90	1027	1300	1448	1604	1769	1941	231
76	175.33	106.30	1041	1317	1467	1626	1793	1967	234
78	179.95	107.69	1054	1334	1487	1647	1816	1993	237
80	184.56	109.08	1068	1351	1505	1668	1839	2018	240
82	189.17	110.42	1081	1368	1524	1689	1862	2043	243
84	193.79	111.76	1094	1385	1543	1709	1885	2068	246
86	198.40	113.08	1107	1401	1561	1730	1907	2093	249
88	203.02	114.39	1120	1417	1579	1750	1929	2117	251
90	207.63	115.68	1132	1433	1597	1769	1951	2141	254
92	212.24	116.96	1145	1449	1614	1789	1972	2165	257
94	216.86	118.23	1157	1465	1632	1808	1994	2188	260
96	221.47	119.48	1169	1480	1649	1827	2015	2211	263
98	226.09	120.71	1182	1495	1666	1846	2035	2234	265
100	230.70	121.94	1194	1511	1683	1865	2056	2257	268
102	235.31	123.15	1205	1526	1700	1884	2077	2279	271
104	239.93	124.35	1217	1541	1716	1902	2097	2301	273
106	244.54	125.55	1229	1555	1733	1920	2117	2323	276
108	249.16	126.73	1240	1570	1749	1938	2137	2345	279
110	253.77	127.89	1252	1584	1765	1956	2157	2367	281
112	258.38	129.05	1263	1599	1781	1974	2176	2388	284
114	263.00	130.20	1274	1613	1797	1991	2195	2409	286

Table 4.10.1(a) Theoretical Discharge Through Circular Orifices (U.S. Gall

Pitot Pressure* (psi)	Feet†	Velocity Discharge (ft/sec)	Orifice Size (in.)						
			2	2.25	2.375	2.5	2.625	2.75	3
116	267.61	131.33	1286	1627	1813	2009	2215	2430	289
118	272.23	132.46	1297	1641	1828	2026	2234	2451	291
120	276.84	133.57	1308	1655	1844	2043	2252	2472	294
122	281.45	134.69	1318	1669	1859	2060	2271	2493	296
124	286.07	135.79	1329	1682	1874	2077	2290	2513	299
126	290.68	136.88	1340	1696	1889	2093	2308	2533	301
128	295.30	137.96	1350	1709	1904	2110	2326	2553	303
130	299.91	139.03	1361	1722	1919	2126	2344	2573	306
132	304.52	140.10	1371	1736	1934	2143	2362	2593	308
134	309.14	141.16	1382	1749	1948	2159	2380	2612	310
136	313.75	142.21	1392	1762	1963	2175	2398	2632	313

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
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 result
particular nozzle must be selected and applied to the figures of the table. The discharge from circular opening
readily be computed by applying the principle that quantity discharged under a given head varies as the square
*This pressure corresponds to velocity head.
†1 psi = 2.307 ft of water. For pressure in bars, multiply by 0.01.

Table 4.10.1(b) Theoretical Discharge Through Circular Orifices (Liters

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)							
			51	57	60	64	67	70	76	
6.89	0.70	3.72	455	568	629	716	785	857	1010	
13.8	1.41	5.26	644	804	891	1013	1111	1212	1429	
20.7	2.11	6.44	788	984	1091	1241	1360	1485	1750	
27.6	2.81	7.43	910	1137	1260	1433	1571	1714	2021	
34.5	3.52	8.31	1017	1271	1408	1602	1756	1917	2259	
41.4	4.22	9.10	1115	1392	1543	1755	1924	2100	2475	
48.3	4.92	9.83	1204	1504	1666	1896	2078	2268	2673	
55.2	5.63	10.51	1287	1608	1781	2027	2221	2425	2858	
62.0	6.33	11.15	1364	1704	1888	2148	2354	2570	3029	
68.9	7.03	11.75	1438	1796	1990	2264	2482	2709	3193	
75.8	7.73	12.33	1508	1884	2087	2375	2603	2841	3349	
82.7	8.44	12.87	1575	1968	2180	2481	2719	2968	3498	

Table 4.10.1(b) Theoretical Discharge Through Circular Orifices (Liters (

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)						
			51	57	60	64	67	70	76
89.6	9.14	13.40	1640	2048	2270	2582	2830	3089	3641
96.5	9.84	13.91	1702	2126	2355	2680	2937	3206	3779
103	10.55	14.39	1758	2196	2433	2769	3034	3312	3904
110	11.25	14.87	1817	2269	2515	2861	3136	3423	4035
117	11.95	15.33	1874	2341	2593	2951	3234	3530	4161
124	12.66	15.77	1929	2410	2670	3038	3329	3634	4284
131	13.36	16.20	1983	2477	2744	3122	3422	3735	4403
138	14.06	16.62	2035	2542	2817	3205	3512	3834	4519
152	15.47	17.43	2136	2668	2956	3363	3686	4023	4743
165	16.88	18.21	2225	2779	3080	3504	3840	4192	4941
179	18.28	18.95	2318	2895	3208	3650	4000	4366	5147
193	19.69	19.67	2407	3006	3331	3790	4153	4534	5344
207	21.10	20.36	2492	3113	3450	3925	4301	4695	5535
221	22.50	21.03	2575	3217	3564	4055	4444	4851	5719
234	23.91	21.67	2650	3310	3668	4173	4573	4992	5884
248	25.31	22.30	2728	3408	3776	4296	4708	5139	6058
262	26.72	22.91	2804	3502	3881	4416	4839	5282	6227
276	28.13	23.50	2878	3595	3983	4532	4967	5422	6391
290	29.53	24.09	2950	3685	4083	4646	5091	5557	6551
303	30.94	24.65	3015	3767	4173	4748	5204	5681	6696
317	32.35	25.21	3084	3853	4269	4857	5323	5810	6849
331	33.75	25.75	3152	3937	4362	4963	5439	5937	6999
345	35.16	26.28	3218	4019	4453	5067	5553	6061	7145
358	36.57	26.80	3278	4094	4536	5161	5657	6175	7279
372	37.97	27.31	3341	4173	4624	5261	5766	6294	7419
386	39.38	27.80	3403	4251	4711	5360	5874	6412	7558
400	40.78	28.31	3465	4328	4795	5456	5979	6527	7694
414	42.19	28.79	3525	4403	4878	5551	6083	6640	7827
427	43.60	29.26	3580	4471	4954	5637	6178	6743	7949
441	45.00	29.73	3638	4544	5035	5729	6278	6853	8078
455	46.41	30.20	3695	4616	5114	5819	6377	6961	8206
469	47.82	30.65	3751	4686	5192	5908	6475	7067	8331
483	49.22	31.10	3807	4756	5269	5995	6570	7172	8454
496	50.63	31.54	3858	4819	5340	6075	6658	7268	8567
510	52.03	31.97	3912	4887	5415	6161	6752	7370	8687
524	53.44	32.71	3965	4953	5488	6245	6844	7470	8806
538	54.85	32.82	4018	5019	5561	6327	6934	7569	8923
552	56.25	33.25	4070	5084	5633	6409	7024	7667	9038
565	57.66	33.66	4118	5143	5699	6484	7106	7757	9144
579	59.07	34.06	4168	5207	5769	6564	7194	7853	9256
593	60.47	34.47	4218	5269	5839	6643	7280	7947	9368
607	61.88	34.87	4268	5331	5907	6721	7366	8040	9478

Table 4.10.1(b) Theoretical Discharge Through Circular Orifices (Liters (

Pitot Pressure* (kPa)	Meters†	Velocity Discharge (m/sec)	Orifice Size (mm)						
			51	57	60	64	67	70	76
620	63.29	35.26	4313	5388	5970	6793	7444	8126	9578
634	64.69	35.65	4362	5448	6037	6869	7528	8217	9686
648	66.10	36.04	4410	5508	6103	6944	7610	8307	9792
662	67.50	36.42	4457	5567	6169	7019	7692	8397	9898
676	68.91	36.79	4504	5626	6234	7093	7773	8485	10002
689	70.32	37.17	4547	5680	6293	7161	7848	8566	10097
703	71.72	37.54	4593	5737	6357	7233	7927	8653	10200
717	73.13	37.90	4638	5794	6420	7305	8005	8738	10301
731	74.54	38.27	4684	5850	6482	7376	8083	8823	10401
745	75.94	38.63	4728	5906	6544	7446	8160	8907	10500
758	77.35	38.98	4769	5957	6601	7510	8231	8985	10591
772	78.76	39.33	4813	6012	6662	7580	8307	9067	10688
786	80.16	39.68	4857	6066	6722	7648	8382	9149	10785
800	81.57	40.03	4900	6120	6781	7716	8456	9230	10880
813	82.97	40.37	4939	6170	6836	7778	8525	9305	10968
827	84.38	40.71	4982	6223	6895	7845	8598	9385	11063
841	85.79	41.05	5024	6275	6953	7911	8670	9464	11156
855	87.19	41.39	5065	6327	7011	7977	8742	9542	11248
869	88.60	41.72	5107	6379	7068	8042	8813	9620	11340
882	90.01	42.05	5145	6426	7121	8102	8879	9692	11424
896	91.41	42.38	5185	6477	7177	8166	8949	9768	11515
910	92.82	42.70	5226	6527	7233	8229	9019	9844	11604
924	94.23	43.03	5266	6577	7288	8292	9088	9920	11693
938	95.63	43.35	5305	6627	7343	8355	9156	9995	11782

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 fou 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 re: on the particular nozzle must be selected and applied to the figures of the table. The discharge from circular o can readily be computed by applying the principle that quantity discharged under a given head varies as the sq

*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 this equation, any units of discharge or pressure drop may 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.

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*
1	1.00	36	6.93	71	9.99	106	12.41	141
2	1.45	37	7.03	72	10.07	107	12.47	142
3	1.81	38	7.13	73	10.14	108	12.53	143
4	2.11	39	7.23	74	10.22	109	12.60	144
5	2.39	40	7.33	75	10.29	110	12.66	145
6	2.63	41	7.43	76	10.37	111	12.72	146
7	2.86	42	7.53	77	10.44	112	12.78	147
8	3.07	43	7.62	78	10.51	113	12.84	148
9	3.28	44	7.72	79	10.59	114	12.90	149
10	3.47	45	7.81	80	10.66	115	12.96	150
11	3.65	46	7.91	81	10.73	116	13.03	151
12	3.83	47	8.00	82	10.80	117	13.09	152
13	4.00	48	8.09	83	10.87	118	13.15	153
14	4.16	49	8.18	84	10.94	119	13.21	154
15	4.32	50	8.27	85	11.01	120	13.27	155
16	4.48	51	8.36	86	11.08	121	13.33	156
17	4.62	52	8.44	87	11.15	122	13.39	157
18	4.76	53	8.53	88	11.22	123	13.44	158
19	4.90	54	8.62	89	11.29	124	13.50	159
20	5.04	55	8.71	90	11.36	125	13.56	160
21	5.18	56	8.79	91	11.43	126	13.62	161
22	5.31	57	8.88	92	11.49	127	13.68	162

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*
23	5.44	58	8.96	93	11.56	128	13.74	163
24	5.56	59	9.04	94	11.63	129	13.80	164
25	5.69	60	9.12	95	11.69	130	13.85	165
26	5.81	61	9.21	96	11.76	131	13.91	166
27	5.93	62	9.29	97	11.83	132	13.97	167
28	6.05	63	9.37	98	11.89	133	14.02	168
29	6.16	64	9.45	99	11.96	134	14.08	169
30	6.28	65	9.53	100	12.02	135	14.14	170
31	6.39	66	9.61	101	12.09	136	14.19	171
32	6.50	67	9.69	102	12.15	137	14.25	172
33	6.61	68	9.76	103	12.22	138	14.31	173
34	6.71	69	9.84	104	12.28	139	14.36	174
35	6.82	70	9.92	105	12.34	140	14.42	175

4.10.2.2 Knowing the values of h_f, h_r, and Q_F, the values of $h_f^{0.54}$ and $h_r^{0.54}$ can be read from the table 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 Insert in Equation 4.10.1.2 the values of $h_r^{0.54}$ and $h_f^{0.54}$ determined from the table and the value of Q_F, and solve the equation 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.

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.

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.

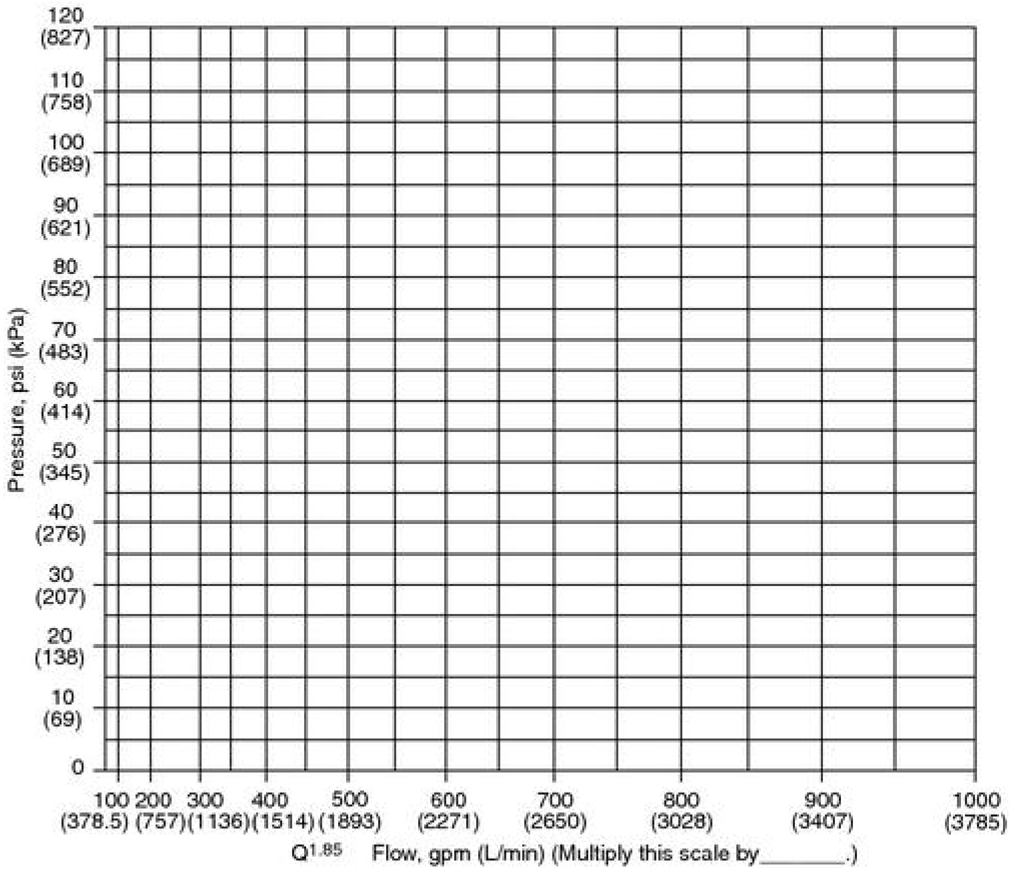


FIGURE 4.11.4 Sample Graph Sheet.

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.

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.

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

Annex B Informational References (Reserved)

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