# NFPA 291

# Recommended Practice for Fire Flow Testing and Marking of Hydrants

## 2007 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

**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.

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Rep. FM Global
**Lynn K. Underwood,** Axis U.S. Property, IL [I]

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

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**Edward K. Budnick,** Hughes Associates, Inc., MD [SE]
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**Robert M. Gagnon,** Gagnon Engineering, MD [SE]
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Rep. Safety to Life Correlating Committee
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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.



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General Motors Corporation, MI [U]
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**James R. Schifiliti,** Fire Safety Consultants, Inc., IL [IM]
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**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]

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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

## 2007 Edition

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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 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.



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## 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.**

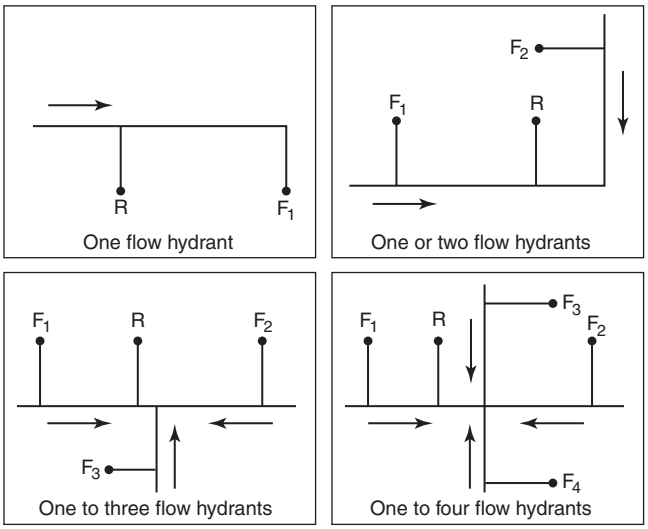
**4.3.1** After the location where the test is to be run has been determined, a group of test hydrants in the vicinity is selected.

**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.




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

**FIGURE 4.3.4 Suggested Test Layout for Hydrants.**

**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 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 1⁄4 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.



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**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.)*

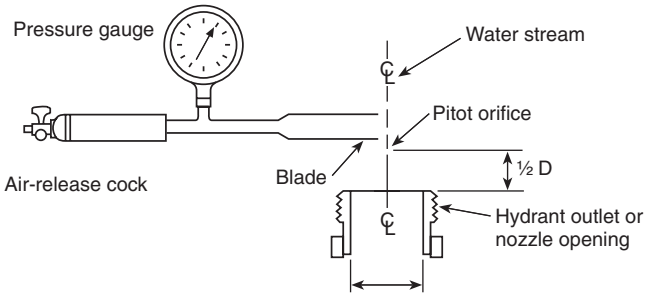



**FIGURE 4.6.9 Pitot Tube Position.**

**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.

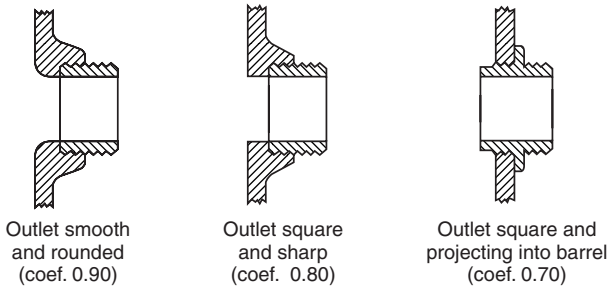



**FIGURE 4.7.1 Three General Types of Hydrant Outlets and Their Coefficients of Discharge.**

**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).

**4.8.3** These coefficients are applied in addition to the coefficient in Equation 4.7.3 and are for average-type hydrants.



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**Table 4.8.2 Pumper Outlet Coefficients**

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

**4.9 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. 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 |



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**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 0.01.



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**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 |



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**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 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.

**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.



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**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.



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**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.**

## 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.

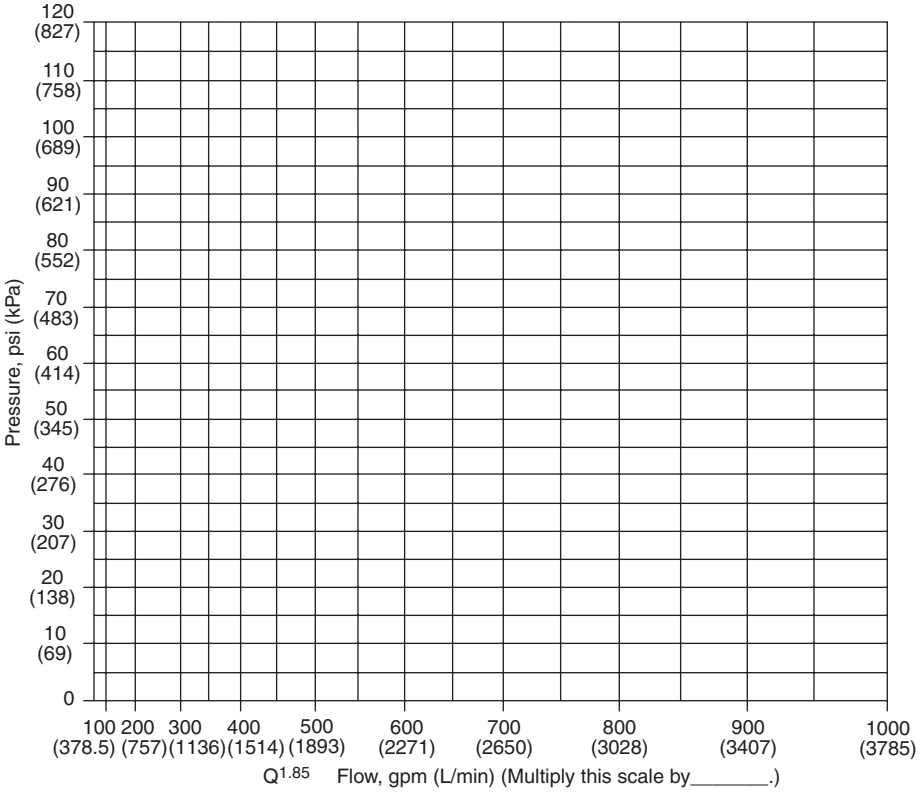



**FIGURE 4.11.4 Sample Graph Sheet.**



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**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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# *Sequence of Events Leading to Issuance of an NFPA Committee Document*

### Step 1: Call for Proposals

- Proposed new Document or new edition of an existing Document is entered into one of two yearly revision cycles, and a Call for Proposals is published.

### Step 2: Report on Proposals (ROP)

- Committee meets to act on Proposals, to develop its own Proposals, and to prepare its Report.
- Committee votes by written ballot on Proposals. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.
- Report on Proposals (ROP) is published for public review and comment.

### Step 3: Report on Comments (ROC)

- Committee meets to act on Public Comments to develop its own Comments, and to prepare its report.
- Committee votes by written ballot on Comments. If two-thirds approve, Report goes forward. Lacking two-thirds approval, Report returns to Committee.
- Report on Comments (ROC) is published for public review.

### Step 4: Technical Report Session

- "*Notices of intent to make a motion"* are filed, are reviewed, and valid motions are certified for presentation at the Technical Report Session. ("Consent Documents" that have no certified motions bypass the Technical Report Session and proceed to the Standards Council for issuance.)
- NFPA membership meets each June at the Annual Meeting Technical Report Session and acts on Technical Committee Reports (ROP and ROC) for Documents with "certified amending motions."
- Committee(s) vote on any amendments to Report approved at NFPA Annual Membership Meeting.

### Step 5: Standards Council Issuance

- Notification of intent to file an appeal to the Standards Council on Association action must be filed within 20 days of the NFPA Annual Membership Meeting.
- Standards Council decides, based on all evidence, whether or not to issue Document or to take other action, including hearing any appeals.

# *Committee Membership Classifications*

The following classifications apply to Technical Committee members and represent their principal interest in the activity of the committee.

M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.

U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.

I/M *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.

L *Labor:* A labor representative or employee concerned with safety in the workplace.

R/T *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.

E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.

I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.

C *Consumer:* A person who is, or represents, the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in the *User* classification.

SE *Special Expert:* A person not representing any of the previous classifications, but who has a special expertise in the scope of the standard or portion thereof.

NOTES;
1. "Standard" connotes code, standard, recommended practice, or guide.
2. A representative includes an employee.
3. While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of members or unique interests need representation in order to foster the best possible committee deliberations on any project. In this connection, the Standards Council may make appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.
4. Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

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**Date** April 1, 200X **Name** John J. Doe **Tel. No.** 716-555-1234

**Company** Air Canada Pilot's Association

**Street Address** 123 Summer Street Lane **City** Lewiston **State** NY **Zip** 14092

**Please indicate organization represented (if any)**

**1. (a) NFPA Document Title** National Fuel Gas Code **NFPA No. & Year** 54, 200X Edition

(**b) Section/Paragraph** 3.3

**2. Proposal Recommends (check one):** ☐ new text ☒ revised text ☐ deleted text

**3. Proposal (include proposed new or revised wording, or identification of wording to be deleted):** [Note: Proposed text should be in legislative format, i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

Revise definition of effective ground-fault current path to read:

3.3.78 Effective Ground-Fault Current Path. An intentionally constructed, permanent, low impedance electrically conductive path designed and intended to carry ~~underground~~ electric fault current ~~conditions~~ from the point of a ground fault on a wiring system to the electrical supply source.

**4. Statement of Problem and Substantiation for Proposal:** (Note: State the problem that would be resolved by your recommendation; give the specific reason for your Proposal, including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

Change uses proper electrical terms.

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**2. Proposal Recommends (check one):** ☐ new text ☐ revised text ☐ deleted text

**3. Proposal (include proposed new or revised wording, or identification of wording to be deleted):** [Note: Proposed text should be in legislative format, i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).]

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